PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

YELLOW WATER MAIN DAM (MT 12)
AND
YELLOW WATER DIKE (MT 3205)
WINNETT, MONTANA
PETROLEUM COUNTY

PREPARED FOR:
HONORABLE THOMAS L. JUDGE
GOVERNOR, STATE OF MONTANA

MONTANA DEPARTMENT OF NATURAL
RESOURCES AND CONSERVATION
(OWNER - ADMINISTRATOR)

YELLOWATER WATER USERS' ASSOCIATION
(OPERATOR)

PREPARED BY:
HKM ASSOCIATES
BILLINGS, MONTANA

SEPTEMBER 1980

SEATTLE DISTRICT
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EXECUTIVE SUMMARY

Personnel of HKM Associates, under a contract with the Montana Department of Natural Resources and Conservation (DNRC), and with representation from the DNRC and the Yellowater Water Users' Association, inspected the Yellow Water Dams on September 26, 1979. The inspection and evaluation was performed under the authority of Public Law 92-367. The project is located on Yellow Water Creek, approximately 9 miles southwest of Winnett, Petroleum County, Montana. Construction of the project was started on December 4, 1935 and completed on June 10, 1938.

FINDINGS AND EVALUATION

Yellow Water Reservoir stores runoff from a drainage of 55 square miles. There are other small storage reservoirs in the Yellow Water Basin but none of significant size. Yellow Water Reservoir feeds downstream irrigation delivery systems as well as Yellow Water Creek. Storage is again provided approximately 13 miles downstream in Petrolia Reservoir.

The Yellow Water Storage Project is multi-purpose in nature as the storage provides water for irrigation, sediment accumulation, floodwater detention, and recreation. Reservoir capacity to the spillway crest is 4500 acre-feet (AF), and 7700 AF to the first overtopping dike crest elevation. The main dam has a hydraulic height of 37 feet, and the dike has a hydraulic height of 11 feet. On the basis of criteria in the U. S. Army Corps of Engineers Recommended Guidelines for Safety Inspection of Dams (Ref. 1), the project is intermediate in size. A breach of either Yellow Water dam or the dike could have a serious impact on Petrolia Dam, possibly even causing an overtopping and failure condition. There are a sufficient number of inhabitable structures in the flood plain downstream of Petrolia Dam such that a failure of the Yellow Water Project could endanger many lives and cause extensive property damage. The downstream hazard potential for both Yellow Water dams is therefore high (Category 1). However, no dam-breach analysis or routing of a dam-breach flood was made and these report findings on probable damage are based on a brief visual inspection, conversation with the project owner and operator, and engineering judgment.

The guidelines recommend that the discharge and/or storage capacity of an intermediate-size, high downstream hazard potential dam be capable of safely handling the Probable Maximum Flood (PMF). The PMF is the flood expected from the

most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. Routing of the estimated PMF developed for this safety evaluation showed that the project is capable of controlling a flood having ordinates approximately equal to 10 percent of the PMF hydrograph ordinates. The embankment materials are classified as being moderately erodible and can be expected to remain stable only for a short period of time under an overtopping condition. A flood event greater than 10 percent of the PMF ordinates results in overtopping and failure of the Yellow Water dams.

The embankments of the Yellow Water dams appear to be stable except for the oversteepened areas on the upstream face of the main dam where the rock riprap has moved downslope. Several seepage areas were identified during the field investigation; however, no seepage-related problems were apparent except for the outlet works conduit. The conduit has experienced serious corrosion and erosion to the extent that the foundation and embankment materials are exposed in isolated locations, thus creating an exfiltration path into the embankment. Past grouting and patchwork has proved to be only a temporary corrective measure.

A comparison of report findings with inspection guidelines shows the Yellow Water Project to have insufficient storage and/or discharge capacity to safely handle one-half of the PMF and therefore the spillway must be considered as seriously inadequate. Also, the corrosion existing in the corrugated steel pipe presents a very serious safety concern. For the above reasons, the Yellow Water Project is considered unsafe-emergency until deficiencies are corrected.

RECOMMENDATIONS

Immediately develop, implement, and test a downstream warning plan, and implement a more active maintenance program. Special immediate attention and rehabilitation efforts must be directed to the outlet works conduit (including that portion upstream of the control gate) because of its severely deteriorated condition, and to the spillway because of its limited hydraulic capacity. Immediately lower the reservoir, inspect the entire outlet facility, and repair or replace the deteriorated pipe and other components. Specific repairs required on the outlet works facility, in addition to the conduit, include the repair of the control gate seat and repair of the outlet structure sidewalls. Observe caution when using the outlet works, whether it be during normal operation, during passage of flood flows, or during the lowering of the pool, so as not to accelerate the deteriorating condition of the conduit. It is recommended that lowering of the pool be performed under the direction of a qualified engineer. The inspection and replacement/repairs need to be accomplished prior to raising the pool. Piezometers need to be installed in the main dam and a regular program developed

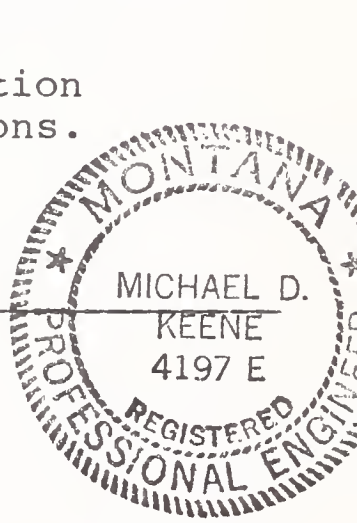
to monitor the piezometric surface, underseepage, and abutment seepage with special emphasis during periods of high reservoir levels. Perform miscellaneous rehabilitation and maintenance in the following areas: on the upstream embankment face by replacing/rearranging riprap, by repairing the erosion gully on the left (north) side, and by removing the bushes; on the crest of the dam and dike by filling and regrading the depressions and ruts; and on the spillway by regrading and by providing protection of the erodible soils.

Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazards and required spillway capacity, and to evaluate embankment stability. Modify the project as studies indicate.

The project operator should contact the Montana DNRC, Dam Safety Section, prior to performing any remedial construction to insure compliance with all pertinent laws and regulations.

Mike Keene

Michael D. Keene, P.E.



PERTINENT DATA SUMMARY

1. General

Federal ID Number - Main Dam	MT 12
Federal ID Number - Dike	MT 3205
Landowner and Project Administrator	Montana Department of Natural Resources and Conservation
Operator	Yellowater Water User's Association
Purpose	Irrigation, Sedimentation, Flood Control, and Recreation
Location	Section 7, T13N, R26E, MPM
County, State	Petroleum County, Montana
Watershed	Yellow Water Creek (tributary to Flatwillow Creek)
Hazard Potential	Category 1 (High)

2. Reservoir

Surface Area at Present Spillway Crest Elevation 992.6 feet	490 acres
Storage to the Low-Level Inlet Elevation 968.0 feet	50 AF
Storage to Present Spillway Crest Elevation 992.6 feet	4500 AF
Storage to the First Over-topping Dike Crest Elevation 998.6 feet	7700 AF
Storage to Design Dam Crest Control Elevation 999.0 feet	8100 AF
Drainage Area	55 square miles
Reservoir Water Surface Elevation on the Day of Inspection 9/26/79	987.5 feet

3. Spillway

Crest Elevation	992.6 feet
Type	Uncontrolled, Broad Crested, and of Earthen Construction
Shape	Trapezoidal
Width	95 feet

PERTINENT DATA SUMMARY
(Continued)

Side Slopes	4H:1V
Spillway Capacity (to First Overtopping Dike Crest Elevation)	3500 cfs
Spillway Capacity (to Design Dam Crest Control Elevation)	3900 cfs

4. Outlet Works

Gates	1-42" Diameter Slidegate Valve
Control	Manual Operator
Conduit	42-inch Diameter CSP
Capacity	
To Spillway Crest	160 cfs
To Low Point on Dike Crest	180 cfs

5. Dams

Main Dam MT 12

Type	Zoned Earth Fill
Structural Height	55 feet
Hydraulic Height	37 feet
Design Dam Crest Control Elevation	999.0 feet
Existing Low Point Dam Crest Elevation	998.8 feet
Crest Length	
Design	1735 feet
Surveyed 10/16/79	1695 feet
Design Crest Width	14 feet
Design Upstream Slope	3H:1V
Design Downstream Slope	2H:1V

Dike MT 3205

Type	Zoned Earth Fill
Structural Height	11 feet
Hydraulic Height	11 feet
Design Dike Crest Control Elevation	999.0 feet

PERTINENT DATA SUMMARY
(Continued)

Existing Low Point Dike Crest Elevation	998.6 feet
Crest Length	
Design	551.0 feet
Surveyed 10/16/79	545.0 feet
Design Crest Width	20 feet
Design Upstream Slope	Unknown
Design Downstream Slope	Unknown

Note: All project elevations are relative to a local survey datum.

CHAPTER 1
BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority

This report summarizes the Phase I inspection and evaluation of the Yellow Water dams. The project is administered by the Montana Department of Natural Resources and Conservation (DNRC), and operated and maintained by the Yellowater Water Users' Association. Reservoir lands are deeded to the State of Montana.

The National Dam Inspection Act, Public Law 92-367 dated 8 August, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' Report to the United States Congress on "National Program of Inspection of Dams" in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive consensus of the engineering community.

Where necessary the guidelines recommend a two-phased study procedure for investigating and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety condition of the dam
(2) based upon an evaluation of the available data and a visual inspection
(3) performed to determine if any needed emergency measures and/or if additional studies, investigations and analyses are necessary or warranted
(4) not intended to include extensive explorations, analysis or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective work.

The responsibility for implementation of these Phase I recommendations rests with the State of Montana, Department of Natural Resources and Conservation. Prior to any action to implement report recommendations, the operator is urged to contact the Montana DNRC. It should be noted that nothing contained in the National Dam Inspection Act, and no action or failure to act under this Act, shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

The investigation process allows for report review by: the Seattle District, Corps of Engineers; the Montana DNRC (project administrator); and the Yellowater Water Users' Association (project operator). Review comments are considered before final publication of the Phase 1 Inspection Report. Their written comments are enclosed in Appendix F.

1.1.2 Purpose and Inspection

The findings and recommendations in this report were based on visual inspection of the project, minimal field survey measurements, and a review of available design and operation data. The purpose of the inspection was to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures. Inspection procedures and criteria were those established by the Recommended Guidelines for Safety Inspection of Dams (Ref. 1).

The visual inspection of the Yellow Water dams was made on September 26, 1979. HKM Associates personnel who attended the field inspection and contributed to this report were:

Dan Dyer, Geotechnical Engineer
Mike Keene, Hydraulics/Hydrology, Team Leader
Dan Nebel, Geology

The project was also inspected by Mr. Al Kersich (HKM Engineer and Principal-in-Charge) on September 30, 1979.

Other HKM personnel contributing to the report but not attending a field inspection were:

Dale R. Cunnington, Structural Engineer
Gary Elwell, Hydraulics/Hydrology

Other personnel present during the September 26, 1979 inspection include:

Glen McDonald, Supervisor, Montana Dam Safety Section
Art Taylor, Dam Safety Engineer, Montana Dam Safety Section
Chris King, Ditch Rider - Yellowater Water Users' Association

Inspections of the Yellow Water dams have historically been performed by the Montana DNRC. It is assumed that the Soil Conservation Service has also inspected the dam because they designed and inspected the 1970-1971 riprap improvement project. One or several representatives of the Yellowater Water Users' Association are generally present during the inspections (Ref. 2).

1.2 DESCRIPTION OF PROJECT

1.2.1 General

The Yellow Water dams are compacted earth fill structures located in the E½ of Section 7, T13N, R26E, M.P.M., Petroleum County, Montana (Appendix A and Ref. 3, 4).

According to the construction drawings (Sheet 2, Exhibit D1), the Yellow Water Storage Project is comprised of 2 dams (Dam No. 1 and Dam No. 2), an outlet works facility, and a 150-foot wide earthen spillway having a crest elevation 7 feet below the dam crest. The spillway was located between Dam No. 1 and Dam No. 2; more specifically it was positioned on the south end of Dam No. 1 embankment. The spillway arrangement was modified in the spring of 1979. This modification included a change in the alignment, length, width and grade of the spillway, and the addition of a dike section along the east side of the spillway to contain

the spillway flows (Exhibit D3). For the purposes of this investigation, old Dam No. 1 will be referred to as Yellow Water Main Dam (MT 12), old Dam No. 2 will be referred to as Yellow Water Dike (MT 3205), and the new dike section along the east bank of the spillway will be referred to as the New Dike Section. The New Dike Section does not act as a containment for the reservoir pool, but rather contains just the spillway flows.

The storage project contains flow from Yellow Water Creek and forms a multi-purpose facility within the Missouri River Basin. Storage water is either released into an irrigation distribution system or returned to Yellow Water Creek. Yellow Water Creek travels approximately 6 miles downstream before joining Elk Creek, and another 7 miles to Petrolia Reservoir (Appendix A and B, and Ref. 3). Petrolia water is either released into an irrigation distribution system or released into Flatwillow Creek. Flatwillow Creek travels another 16 miles before joining the Musselshell River. The nearest downstream community is Mosby, Montana, which is located on the east bank of the Musselshell River approximately 21 miles northeast of the Petrolia Dam and 30 miles east-northeast of the Yellow Water Project (Ref. 3 and 5).

The Yellow Water dams are constructed on property deeded to the State of Montana, with a total of 473 acres deeded for the reservoir pool right-of-way. The State of Montana administers the project and the Yellowater Water Users' Association performs the operation and maintenance (Ref. 6, 7, 8).

Outflow facilities for the Yellow Water Storage Project consist of a low-level outlet and a spillway. The low-level outlet is located on the left (north) side of the main dam at the contact of the valley wall. It is a 42-inch corrugated steel pipe having a control gate near the centerline of the dam axis. The spillway is located between the main dam (Dam No. 1) and the dike section (Dam No. 2). The spillway is an uncontrolled, trapezoidal, earth structure having an approximate base width of 95 feet and is constructed on nearly a horizontal gradient for about 500 feet at which point it transitions to the natural terrain.

Yellow Water Main Dam and Dike have a hydraulic height of 37 feet and 11 feet, respectively. The project impounds approximately 7700 acre-feet (AF) at the first overtopping dike crest elevation (998.6 feet). Based on a visual reconnaissance and engineering judgment, there is 1 farmstead located in the flood plain between Yellow Water Reservoir and Petrolia Reservoir, and approximately 3 farms/ranches downstream of Petrolia Dam along Flatwillow Creek until reaching the confluence with the Musselshell River. In addition to inhabitable structures, there are private roads, bridges, irrigation distribution systems, and agricultural land that will be affected by a sudden breach of either the Yellow Water or Petrolia Project. On the basis of this

information and in accordance with the Recommended Guidelines (Ref. 1), the project is classified intermediate in size and the downstream hazard potential is high (Category 1).

The Yellow Water Project was constructed primarily to provide storage and regulation in support of irrigation practices. Incidental capacity is provided for sediment accumulation, floodwater detention, and recreation. Storage to the normal pool level, or the present spillway crest (elevation 992.6 feet), is 4500 AF. An additional 3200 AF are available for flood surcharge storage between the spillway crest and the first overtopping dike crest elevation.

Yellow Water Reservoir has an upstream contributory drainage area of 55 square miles. The Yellow Water Creek watershed is characterized by both foothill and prairie drainages. Elevations in the basin range from about 4400 feet msl in the foothills of the Little Snowy Mountains to about 3200 feet msl at the reservoir (Ref. 3). The reservoir is located primarily in open range country with some scattering of large cottonwood trees along the creek bottom. The terrain bordering the reservoir is generally flat to gently rolling (Photos 8, 9, and 10 of Appendix C).

1.2.2 Regional Geology

Yellow Water dams are situated in the Great Plains province on Yellow Water Creek in central Montana in a topography of high buttes and broad undulating plains broken by numerous gullies and valleys. Structurally, the dams are located near the axis of a broad anticline in a transition area between two large structural provinces: the Blood Creek syncline-Cat Creek anticline to the north and east, and the Snowy Mountain uplift to the west. The strata in the area dip gently to the east with soft shale beds of the Colorado group forming the surrounding plains. Immediately north of the dams, igneous rocks in the form of volcanic necks, dikes and sills form high rounded buttes. Some faulting and fracturing has occurred near these extrusions, however no faults were noted in the immediate area and none have been noted by previous investigators (Ref. 9).

1.2.3 Seismicity

The Yellow Water Project is in a relatively quiet seismic zone with the majority of the region's seismic events occurring in the southwestern Montana-Yellowstone Park area. Since 1925, Montana has experienced five shocks that reached intensity VIII or greater (Modified Mercalli Scale). The closest epicenter occurred at Helena, Montana which is approximately 180 miles west of the damsite. No shocks of intensity IV or greater have been reported within a 100-mile

radius of the site (as of January, 1974). The dams are located in Zone 1 of the seismic zone map as shown in Reference 1. The seismic probability of Zone 1 is one of minor damage and is based on known distribution of damaging earthquakes and their associated intensities. In general, dams in seismic Zone 1 may be assumed to present no hazard from earthquakes provided static stability conditions are satisfactory and conventional safety margins exist (Ref. 1, 10).

1.2.4 Site Geology

Limited drill hole information is available for the site. A subsurface profile drawing is shown on Sheet 2, Exhibit D1. Information from surficial interpretation and the site drilling program were used to develop this section.

The reservoir basin is formed in a sandy shale sequence with 5 to 10-foot sandstone beds forming ledges throughout the area. The valley section consists of alluvial deposits of sandy and silty clays which, based on the site drawings, are 20 feet or less in depth. No large areas of slope instability were noted in the reservoir basin, which is generally expected because of the gentle slopes in the basin. However, some areas of wave undercutting were observed.

The outlet works and its stilling basin are located in alluvium which has been protected by mortared riprap. A new spillway has been constructed in sandy shale material on the right side between the main dam and the dike section.

1.2.5 Sedimentation

The catchment area above Yellow Water Reservoir consists primarily of natural grass-covered range land with some subirrigated lands. Siltation was evidently not considered a critical factor in the original design as no mention was made of siltation in the available correspondence and design files. Post-construction investigations and operation and maintenance (O & M) reporting have also excluded comments relative to sedimentation. There is no evidence that sediment studies have been or are currently being performed at the reservoir or in the watershed (Ref. 2, 6, 7, 8). The site field investigation did not reveal any evidence of siltation problems.

1.2.6 Design and Construction History

The Yellow Water Storage Project was designed and constructed by the Montana State Water Conservation Board (SWCB). Construction was financed with SWCB funds, and labor was furnished by the Civilian Conservation Corps. The SWCB furnished equipment, fuel, repairs, and at certain times cooperated in the payment of outside labor. Project construction started on December 4, 1935, and reached completion on June 10, 1938 (Ref. 7, 8).

The project essentially laid dormant with only sporadic use of the water until 1947. On December 1, 1947, eight water purchase contracts were executed for downstream water service.

The Yellowater Water Users' Association was incorporated on April 27, 1948, and on May 12, 1948 a water marketing contract was established between the SWCB and the water user's association. Under this contract, the Association and its members agreed to repay the SWCB all the funds it had invested at that time, plus any future investments, at an assigned interest rate (Ref. 7, 8).

Only a limited amount of design and construction data for the Yellow Water Project was available for review. Three construction drawings were reviewed (Exhibit D1 of Appendix D), but even these were not identified as representing "as-constructed" conditions. The drawings did indicate that 21 test pits were made in the immediate area of the embankment and dike. No test pits were indicated in the area designated for borrow. Soil borings and physical property test results for pre-construction and construction soil conditions were not available for review.

Since completion of the Yellow Water dams, the Montana Department of Natural Resources and Conservation (DNRC) and the local water user's association have performed some repair and improvement work. In 1970, a riprap facing and gravel filter blanket were designed by the Soil Conservation Service (SCS) for the upstream slope of the embankment. The SCS performed a final inspection of the work in May 1971. Minor repair work on the outlet works conduit has been performed in recent years; in particular, holes in the pipe wall, and the entire pipe invert downstream of the control gate, have been grouted.

A new spillway channel was constructed in the spring of 1979 by Hugh Brindley of Winnett, Montana. Severe erosion was developing downstream of the old spillway crest and in the return channel, and corrective measures were considered necessary to maintain structural integrity of the main dam embankment (Ref. 2, 6, 7 and Section 2.1.1 - Spillway).

CHAPTER 2
INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Spillway

The spillway for the Yellow Water Storage Project is located on the right (south) side of the dam between the main dam and the dike section. The present configuration differs from that shown on Sheet 2 of Exhibit D1. The new spillway channel was constructed in the spring of 1979 as a corrective measure for localized erosion. Its entrance occupies approximately the same position as the old spillway, but then aligns in a north-south direction rather than the old northwest-southeast direction. A new dike section has been constructed across the old spillway channel to direct the spillway flows into the new channel (Sheet 2 of Exhibit D1 and Exhibit D3). The new spillway had not operated since the modification was completed. However, a representative for the project operator (Yellowater Water Users' Association) indicated that historically the old spillway operated, on the average, 3 out of every 5 years.

The existing spillway is an earthen, broad-crested, uncontrolled outflow system. The channel is trapezoidal in shape with a minimum base width of 95 feet and has approximate side slopes of 4:1 (horizontal to vertical). The spillway channel is contained by natural ground and an old dike section (Dam No. 2) on the right (west) side, and the new dike section on the left (east) side. The channel was excavated a short distance into sandy shale material, which should reduce the erosion potential along the flowline (Photos 14, 20-23 of Appendix C). The channel extends approximately 500 feet on nearly a horizontal slope from the inlet to a point where the channel transitions to natural terrain. From there, the spillway discharge travels primarily as overland flow until returning to the Yellow Water Creek channel and flood plain (Photos 13 and 15). A centerline profile and typical cross section of the existing spillway were measured in October 1979, and are provided on Sheet 4 of Exhibit D1. The spillway crest elevation for the new facility is 992.6 feet (local datum).

Original hydraulic rating information for spillway operation was not available for review; however, even if available, it would not be applicable because of the 1979 reconstruction. The 1979 inspection and survey data was used to define the hydraulic characteristics of the spillway. To develop the hydraulic rating information, a backwater profile analysis was performed from the break-in-slope at the downstream end of the defined channel to the reservoir pool. The backwater profile analysis was performed using the U. S. Army Corps of Engineers' computer program HEC-2 (Ref. 11). Critical

depth was assumed at the slope break (Profile Sta. 5+00, Sheet 4 of Exhibit D1) to start the backwater model. A Manning's "n" value of 0.022 was used and allowance was made for entrance losses. Spillway capacity to the existing low-point embankment elevation (998.6 feet) is estimated to be 3500 cfs. Spillway rating data is provided in Exhibits E2 and E3 of Appendix E.

The spillway was noted as being generally in excellent physical condition at the time of the September 1979 inspection, primarily because it had not operated to that date (Photos 20-23). It is anticipated, however, that some channel bank erosion will be experienced in the future unless some means of stabilization is provided. This potential problem is particularly true for the left spillway bank, and during high flows when the average flow velocities in the channel will approach 10 feet per second. Erosion potential along the right spillway bank, which is the dike section containing the reservoir pool, is not as great. Hence, localized bank erosion should not create a safety hazard to the reservoir containment structures. It is also anticipated that localized scour holes are likely to develop along the spillway floor with some local disconfiguration. Extensive or deep cutting along the flowline is not expected because of the sandy shale barrier. The field inspection and survey revealed that the spillway channel was constructed with an unfavorable bed slope; in fact, it is quite irregular and even an "adverse" slope in some reaches (Sheet 4 of Exhibit D1).

2.1.2 Outlet Works

The outlet works for the Yellow Water Project is located about 375 feet from the left (north) abutment contact of the main dam, and is aligned approximately along the left valley wall. The construction plans indicate that the outlet works facility consists of a concrete intake structure, a 42-inch diameter conduit, a wet-well chamber with a control gate, an outlet structure, and an irrigation water delivery canal. Construction plans are provided in Exhibit D1 of Appendix D.

The intake structure was designed to include concrete side-walls and a headwall, and a metal trashrack. Flowline elevation for the intake was set at 968.0 feet (local datum). It was not possible to inspect this structure during the field investigation due to the reservoir level, and hence, "as-constructed" conditions were not verified and physical condition was not established.

The outlet conduit was field-checked to be a 42-inch diameter corrugated steel pipe (CSP). Total conduit length from the intake structure to the outlet structure is about 150 feet. The conduit was inspected only from the control gate downstream

to the outlet. The pipe invert had been grouted or paved in the past to protect and/or cover severely eroded pipe sections. Some of this grout material is deteriorating; in fact, a large portion has been removed by erosion immediately downstream of the gate. It is possible to feel the earth and gravel foundation below the pipe where the grout section has been removed. Some interior bituminous coating was still evident along the conduit, particularly above the normal flow line. Moderate to severe erosion and corrosion of the pipe material was evident throughout the pipe interior. There are many rocks, as large as 12-inches in diameter, located along the pipe invert. The horizontal alignment of the conduit is good.

At the 85-foot distance upstream of the outlet, the mastic joint covering is badly deteriorated. At this same point, there is a depression in the pipe crown. There is a significant inward bulge in the pipe sidewall approximately 80-feet upstream of the outlet. Grout has been injected in the pipe sidewall 18 inches from the outlet (Photo 19 of Appendix C).

The wet-well chamber is a concrete structure located about 20 feet upstream of the Yellow Water Main Dam centerline (Photos 1 and 8 of Appendix C). The chamber contains a 42-inch diameter slidegate, gate operator, flashboard guides, and a ladder (see the construction plans, Sheet 3 of Exhibit D1). A metal cover was placed over the chamber between July 1975 and November 1976 to eliminate a safety hazard and possibly reduce the amount of debris being deposited/carried through the conduit (Ref. 2). The following specification for the slidegate was obtained from the inspection report file (Ref. 2): 1-42" Hardesty 2042-8A.

For inspection purposes, the operating gate was closed and the conduit partially pumped/drained. Complete "seating" of the gate was not possible as water continued to seep into the conduit after complete closure. Leakage was observed along the gate contact point at the pipe crown.

It is assumed that additional inflow to the conduit while the gate is closed is associated with the hole in the pipe invert immediately downstream of the gate. It was difficult to quantify this amount because of nearly 1-foot of standing water in the pipe.

The exterior concrete walls for the chamber appeared to be in good condition. The interior and the condition of the ladder was not observed due to the water height in the well. The metal cover for the tower was in place at the time of the inspection. Assuming the trash rack was installed on the inlet structure as shown on Sheet 3 of Exhibit D1, it

can be concluded that the rocks currently scattered along the pipe invert entered the system prior to the placement of the metal cover on the tower in 1975-1976.

The outlet structure presently consists of mortared rock sidewalls and a mortared rock headwall. The sidewalls are slightly flared in transitioning from the 42-inch diameter pipe to a small stilling basin (Photos 16 and 18 of Appendix C). The mortar has deteriorated along the sidewalls and rock has dropped into the stilling area. Bank erosion has occurred downstream of the mortared rock sidewalls (Photo 16).

A small irrigation canal conveys the reservoir releases downstream as part of the irrigation delivery system. The canal is unlined, is trapezoidal in shape, and has well vegetated banks. Other than some bank sloughing, the canal appeared to be in good condition (Photos 16 and 17).

Outlet works capacity data was not available for review; consequently, hydraulic rating information had to be redeveloped. To estimate system capacity, it was assumed that the control gate is in the fully open position, that the conduit is flowing full with a Manning's "n" of 0.022, and that the inlet and outlet structures are unobstructed. Capacity to the spillway crest (elevation 992.6 feet) is estimated to be approximately 160 cfs, and 180 cfs to the first overtopping dike crest elevation. Complete outlet works rating data is provided in Exhibits E2 and E3 of Appendix E.

2.1.3 Freeboard

Flood routing indicates the dams overtop during the guidelines' (Ref. 1) recommended spillway design flood (PMF), therefore, there is no freeboard. At the time of the field inspection, the reservoir water surface elevation was approximately 987.5 feet (local datum), or 5.1 feet below the current spillway crest elevation. Relative to the first overtopping dike elevation (998.6 feet) the vertical distance to the water surface at the time of the survey was 11.5 feet. The historical highwater level is estimated to be elevation 992.5, which has an associated freeboard of 6.1 feet. Debris lines along the upstream face of the dams, and water marks on the control tower, provided field evidence of highwater levels.

The minimum design freeboard for the Yellow Water Project was apparently established at 3.0 feet (Ref. 8), which was equivalent to a pool elevation of about 996.0 feet. The 3-foot allowance is barely enough to cover the wave height according to today's standards. Yellow Water Reservoir is basically oriented in an east-west direction, with the dams on the east side. The prevailing wind for this region is generally identified as being westerly (Ref. 12, 13). The reservoir location and orientation can be observed in Appendices A and

B. The effective fetch length is estimated to be 1.5 miles. Hence, a minimum freeboard allowance between the maximum water surface elevation during the spillway design flow (SDF) and the dam crest should be 4.5 feet (Ref. 14). This 4.5-foot minimum allowance does not necessarily apply to an event as severe as the PMF where the design objective would be to provide only enough freeboard to maintain structural integrity of the dam.

2.2 HYDROLOGY

2.2.1 Physiography and Climatology

The 55-square mile catchment area above Yellow Water Reservoir is basically rectangular in shape, with the length dimension approximately twice the width. In particular, the drainage area is approximately 12 miles long and 5.5 miles wide. The topography includes flat plains, rolling prairies, and foothills. The immediate vicinity of the reservoir can primarily be characterized as plains topography. The watershed rises from the reservoir in a westerly direction by gradual slopes and bench lands to higher elevations in the foothills of the Little Snowy Mountains.

Soils along the stream bottoms are generally sandy loams and gravels. Bench-land soils commonly range from clay loams to silty clay loams, becoming gravelly with depth (Ref. 15).

The regional climate is classified as distinctly continental, and characterized by abundant sunshine, low relative humidity, light rainfall, and wide daily and seasonal variation in temperature. However, the regional climate does not have the extreme variable pattern common to the more mountainous western sections of Montana. In general, the valleys are relatively dry during the colder months and wet during the late spring and early summer. The wettest part of the year in the Little Snowy Mountains is generally from midwinter to early spring. Snowfall in the prairie sections of the Yellow Water watershed is generally light and does not tend to remain on the ground for long periods of time. It is not uncommon for the region to experience winter warming spells with associated thawing temperatures. Annual precipitation averages about 13.5 inches at Flatwillow 4 ENE, a climatological station located 8 miles southeast of the dams. The average annual temperature at Flatwillow is approximately 45°F. Winters are typically cold, with January being the coldest month. The monthly average temperature for January at the Flatwillow climatological station is about 20°F. During the summer, July is typically the warmest month with an average temperature of about 70°F (Ref. 12, 13, 15).

The U.S. Geological Survey has historically accumulated streamflow data on Flatwillow Creek, a neighboring stream to Yellow Water Creek and the main tributary to Petrolia Reservoir. Measurements were obtained at two different locations along Flatwillow Creek in the past. Flatwillow Creek near Flatwillow, Montana (gage number 06127900) has the longest record of the two, with 41 years of peak flow measurements. Drainage area above this particular gage is 188 square miles. The historic peak flow occurred in June 1917 when 954 cfs passed the gaging station, which is equivalent to a watershed yield of 5 cfs per square mile. To emphasize the peak runoff pattern for the region, 11 of the 41 annual peak events on Flatwillow Creek occurred in May and 18 occurred in June (Ref. 16).

The other stream gage maintained by the U. S. Geological Survey is identified as Flatwillow Creek near Winnett, Montana (gage number 06128200). This gage was located immediately downstream from Petrolia Dam and had an upstream drainage area of 642 square miles. The period of record for peak discharge measurements is as follows: 1923 - 1925, 1927 - 1929, 1931 - 1932, 1946, 1950 - 1951. Most of these annual peak events occurred in June (Ref. 16).

A regular monitoring program of the Yellow Water Reservoir water surface is not maintained. Occasional measurements of the reservoir contents are made by a measuring tape in the outlet works control tower. Historical water level measurements were not available for review.

2.2.2 Estimated Probable Maximum Flood (PMF)

The probable maximum precipitation (PMP) and the estimated probable maximum flood were developed for the Yellow Water drainage basin. The PMF is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the study region. The PMF is derived from the PMP with appropriate consideration of snowmelt contributions.

Yellow Water Reservoir is located west of the 105th meridian and east of the Continental Divide, hence PMP values were calculated using procedures contained in the U.S. Weather Bureau's Technical Paper 38 (Ref. 17). TP-38 provided PMP values for durations to 24 hours, with extensions to 48-hour and 72-hour durations made by applying a factor of 110 percent and 115 percent respectively. After applying the suggested areal reduction factors for the 55-square mile drainage, the PMP 6-hour, 12-hour, and 24-hour precipitation amounts were 14.3 inches, 17.2 inches, and 20.0 inches, respectively. The 48-hour amount was determined to be 22.0 inches, and the 72-hour was 23.0 inches.

The 6-hour increments for the total 72-hour storm were arranged in a critical distribution using criteria presented in the U.S. Weather Bureau's Hydrometeorological Report No. 43 (Ref. 18). In particular, the 6-hour rainfall increments were arranged according to pattern "e". Further subdivision of the calculated rainfall increments was required to provide compatibility with the duration of the unit hydrograph. A 30-minute unit hydrograph was selected for Yellow Water Reservoir using criteria presented in the SCS Hydrology Handbook (Ref. 19). The PMP storm was plotted in the form of a depth-duration curve for convenience in selecting incremental rainfall values. The 30-minute PMP values within the peak 6-hour increment were ordered according to the reverse pattern of the unit hydrograph ordinates.

Rainfall losses were assumed equal to zero due to assumed ground conditions. Hence, excess rainfall was assumed equal to the rainfall amounts.

The runoff condition, or PMF, resulting from a PMP storm was estimated using the PMP values and the unit hydrograph approach. A 30-minute unit hydrograph was developed for the Yellow Water basin using the U.S. Army Corps of Engineers' computer program HEC-1, and the SCS method (Ref. 20). The resultant PMF has a peak flow of approximately 118,900 cfs and a total runoff volume of 67,300 AF.

2.2.3 Flood Routing

The PMF resulting from the PMP rainfall/runoff event was routed through Yellow Water Reservoir using the computer program HEC-1 (Ref. 20). Runoff from an antecedent storm was not specifically considered; however, it appears reasonable to assume the initial reservoir level prior to routing the PMF is at the spillway crest (elevation 992.6 feet). The support rationale for this assumption is that Yellow Water Reservoir characteristically has a small reservoir pool and is not capable of totally absorbing rather severe flood events. A relatively rapid drawdown of the reservoir pool can be accomplished with the 42-inch outlet conduit. However, it is not likely that the project would be operated in this manner unless it was on an emergency basis. The water users would prefer to store as much water as possible in preparation for the irrigation season. Also to be considered in releasing high discharge rates through the outlet works is the probable structural damage that would result relative to the outlet works conduit, possibly the main dam embankment in the vicinity of the conduit, and the return channel. In summary, the "sense of emergency" is not likely to be realized by the project operators to the extent storage water and structural damages would be sacrificed in anticipation of a PMF event.

Reservoir area-capacity-elevation data was obtained from DNRC reports (Ref. 6, 7), and is provided in Exhibit E1 of Appendix E. Yellow Water discharge rating data is provided in Exhibits E2 and E3.

Flood routing studies indicate that during the full PMF, the dams would be overtopped when 11 percent of the flood volume had entered the reservoir. Routings were made of lesser hypothetical floods than the PMF to determine the magnitude of floods the project can safely contain. The hypothetical hydrographs are obtained by applying the same percentages to all PMF ordinates. A flood having ordinates corresponding to 10 percent of the PMF ordinates is just controlled by the project. Larger floods would overtop the dams. It should be realized, however, that the Yellow Water Project may have the storage and outflow capacity to accommodate flood events as severe as 10 percent of the PMF, but the project may not be capable of safely handling these floods. Of particular concern is the outlet works which may not be capable of maintaining structural integrity under this type of loading.

2.3 GEOTECHNICAL EVALUATION

The geotechnical evaluation of the Yellow Water Project included a field investigation and a search and review of project design data. The field inspection consisted of photo documentation, a dam crest profile survey, observations of the dam embankments, seepage observations, and measurements of the slope angles. Inspection photos are included in Appendix C, project drawings are provided in Exhibit D1 of Appendix D, and the crest profile survey is shown in Exhibit D2. Results of the slope angle measurements are provided in Exhibit D3.

2.3.1 Dam Embankment

Yellow Water Dam is a compacted, zoned, earth fill structure which was completed in 1938. The main dam has a maximum structural height above the deepest point on the foundation surface of 55 feet. The main dam embankment crest length and width are 1735 and 14 feet, respectively. The dike embankment is about 550 feet long and has a crest width of nearly 20 feet. An earthen spillway (see Section 2.1.1 for details) is located between the main dam and dike embankment. The construction plans indicate the upstream and downstream slopes of the main dam were designed with slopes of 3:1 and 2:1 (horizontal to vertical), respectively. Slope angle measurements indicate the upstream slope is presently about 2:1 above the water surface. This is likely the result of a combination of factors: first, the riprap has been slightly undercut; and second, additional riprap was added to the upstream face in 1971. The additional riprap above the

water line created a steeper slope. The downstream slope is nearly 2:1 at the top then appears to flatten below a berm located near elevation 988.0 (local datum). The slopes of the dike section appear to vary from 4:1 to 2:1. Riprap has been placed on the upstream face of the dike section.

The small berm on the downstream face of the main dam is about 6 feet wide (Photo 4). The plans indicate this berm was originally designed with a backslope to serve as a runoff collection ditch. Presently, this berm is disfigured and has a positive slope away from the embankment. There is a moderate to sparse cover of natural grasses, weeds, and sagebrush on the downstream slope (Photos 4-7).

The plans provided in Exhibit D1 of Appendix D indicate that the embankment cross section consists of five parts identified as the impervious earth fill, the pervious earth fill, a rock toe, pit run gravel (transition from rock toe to pervious section), and the select gravel drain. The design characteristics (gradation, plasticity, etc.) are not specified in the drawings nor the project files. The impervious section is located in the upstream and central region of the embankment while the pervious section is on the downstream side. There is a cutoff trench located at the base of the impervious section on the upstream side of the main dam embankment. Construction drawings indicate that the cutoff trench extends into the underlying shale foundation approximately 3 feet (Exhibit D1 of Appendix D).

2.3.2 Foundation Conditions and Seepage Control

The drawings indicate that 21 test pits were made in the immediate area of the embankment and dike. It does not appear that borings were made. The test pits did not penetrate the shale more than about 1 foot. No test pits were made in the area designated for borrow on the drawings.

Engineering and physical property test results on the soils in the area are not available in the design file.

Based on the construction drawings and the available information, it appears that the main section of the existing dam embankment is resting primarily on alluvial deposits of sand and clay up to about 20 feet thick.

In the dike area, there is up to 5 feet of clay. The sand and clay is underlain by sandstone and shale. This bedrock is laminated and fractured in some isolated locations.

Settlement

The construction plans indicate that the dam crest control was established at elevation 999.0 feet (local datum). An embankment profile was surveyed on October 16, 1979 (Exhibit D2 of Appendix D). The survey shows that the maximum differ-

ential elevation along the crest is about 1 foot. The differential elevations are apparently the result of a combination of inadequate construction control, minor settlements, and a high traffic volume along the crest. It appears the dam was designed without camber.

Settlement along the outlet conduit appears to be small. The observed deformations in the conduit crown and wall appear to be more related to installation procedures and pipe strength rather than post-construction settlements. A detailed description of the conduit is presented in Section 2.1.2. Conduit alignment upstream of the wet-well chamber was not observed because it necessitates an almost complete reservoir drawdown for inspection. In summary, embankment and foundation settlements appear to be minor. Additional settlements are expected to be negligible.

Seepage Control

At the time of the September 1979 field investigation, Yellow Water Reservoir was at a relatively low level (elevation 987.5 feet, or 5.1 feet below the spillway crest). Two general seepage areas were identified during this investigation: near the left abutment on the downstream side, and below the old spillway area. The seepage on the left abutment appears to be passing through the bedrock formation which is a laminated sandstone, and exiting below the embankment contact. Although free water from the abutment area was not observed, the seepage is evidenced by the saturated soils and heavy vegetation (Photo 26).

A similar condition exists below the old spillway area on the right abutment (Photo 27). The seepage exits at a location where the bedrock is exposed about 150 to 300 feet below the spillway area.

Neither of these seepage conditions have apparently saturated the embankment materials nor is there evidence that they have significantly affected the foundation integrity.

Clear seepage water was observed exiting from the rock toe of the main embankment section (Photos 5, 6, and 7). This seepage is controlled by a main drain, which is parallel to the dam axis, and a series of lateral gravel drains which are perpendicular to the axis. The drain system is located at the base of the pervious fill section for controlled collection and discharge of seepage water to the pervious rock toe. Seepage was observed along most of the rock toe (Photo 28). This condition has saturated the foundation soils along the downstream toe. Evidence does not suggest that a significant amount of seepage is passing under the structure.

A relatively large body of standing water is located about 100 feet below the main dam. The seepage through the dam does contribute to this pool, however, most of this water is likely coming from leaks in the irrigation ditch works (outlet channel) several hundred feet below the embankment.

No seepage was evident through the dike section.

2.3.3 Stability

Embankment

The slope angles measured during the field investigation are shown in Exhibit D3 of Appendix D. These angles were measured with an Abney level and should be considered approximate.

There is no outward stability distress evident from visual inspection of the dam embankment. However, there is no stability analysis data available to evaluate the dam design. Available design information suggests that soil strength tests were not performed and stability calculations were not made. There are no piezometers in the dam and the position of the phreatic surface is unknown. Sufficient data is not presently available to evaluate the embankment stability.

Erosion

At an isolated location on the upstream face of the embankment, the riprap has moved downslope along the embankment leaving the slope exposed and oversteepened (Photo 2, 3, and 25). This entire area, as identified on Exhibit D3, needs to be repaired.

The reservoir shorelines are considered to be in stable condition as no major slides or scarpments were observed. The shoreline is occasionally vertical, or near vertical, and localized sloughing occurs due to wave action and saturated conditions (Photos 9, 10, 11, 12, and 21).

2.3.4 Rock Riprap

Rock riprap has been placed on the upstream face of the dam and in the stilling areas of the outlet works. This rock is sandstone and is generally erosion resistant. Some weathering is evidenced by the rounding of the edges and the decrease in size of the stone below the water level (Photos 18 and 24). In some locations on the upstream face the quantity of the riprap appears to be deficient. These areas are generally oversteepened and vulnerable to rapid erosion, and should be repaired.

The walls of the stilling area immediately below the outlet conduit are constructed of rock with a mortar binder. This structure has experienced considerable deterioration, particularly along the sidewalls (Photos 16 and 18).

The riprap in the bottom of this stilling area is almost nonexistent, except for the rock which has dropped into the area from the sidewalls. Remedial measures should be made to eliminate further sidewall deterioration and to enhance bank stabilization.

2.4 PROJECT OPERATIONS AND MAINTENANCE

The Yellow Water Storage Project is administered by the Montana DNRC through a contractual agreement with the Yellowater Water Users' Association (Ref. 7,8). Initially, the State Water Conservation Board (SWCB) had the responsibility to construct, operate and maintain water conservation projects. In 1967, the SWCB was replaced by the Montana Water Resources Board (MWRB). The new agency shifted its emphasis from construction activities to providing engineering services for local groups and water user associations, to assisting in the maintenance of previously constructed projects, and to conducting annual maintenance inspections. Responsibility for project operation and maintenance gradually shifted from the state agencies to the local groups over a period of years. Upon reorganization of state government in 1971, the MWRB was replaced by the Department of Natural Resources and Conservation (DNRC). Accounting and engineering responsibilities were departmentalized, with the Engineering Bureau of the Water Resources Division, DNRC, delegated the responsibility to provide the services previously mentioned for the MWRB. At the present time, the Yellowater Water Users' Association performs essentially all operation and maintenance activities and the state agency serves only in a supervisory capacity (Ref. 2, 7, and 8).

Representatives of DNRC maintain frequent contact with the water user group by attending important meetings, and by scheduling regular inspections of the project. They also advise the group of maintenance, repair, operation and budgetary needs. The DNRC provides assistance and direction in determining the best repair alternatives and financing sources (Ref. 2, 7, and 8).

Releases from the reservoir are generally dictated by seasonal requirements. Seasons of particular interest are the spring and early-summer runoff period, and the irrigation period. Releases during the irrigation season are monitored and controlled according to water rights and needs. Reservoir pool carry-over from year to year also plays a part in project operation. No operations manual for the project has been prepared, and minimal operating records are maintained for components of the storage and water delivery system.

Miscellaneous maintenance work has been accomplished in the past on the main dam and related structures. However, this activity has been limited due to manpower and budgetary constraints. Project history and inspection reports have been maintained by the Montana DNRC and are provided in Ref. 2, 6 and 7.

2.4.1 Dam

There is no formal plan for periodic maintenance of the Yellow Water dams. The only major improvement relating specifically to the dam was the placement of a gravel filter blanket and rock riprap on the upstream face of the dam. This particular work was designed by the SCS in 1970, and completed in 1971 (Ref. 2, 6, and 7). The Montana DNRC performs regular inspections of the project and provides maintenance suggestions (Ref. 2).

2.4.2 Reservoir

Yellow Water Reservoir water surface elevation is measured on an irregular basis by the local water users' association, and during project inspections. Water deliveries are made by a water commissioner with the aid of measuring devices and the gate stem height on the outlet works control valve. Maintenance and repairs specific to the reservoir shoreline, or any implementation of watershed management practices upstream in the basin, have not been recorded in the files.

2.4.3 Related Structures

The spillway is an uncontrolled facility. Releases through the outlet works is controlled by the ditch rider and/or the local water commissioner.

A new spillway section was recently constructed (spring 1979) as a replacement to the original design. Severe erosion was developing in the old facility downstream of the spillway crest and in the return channel. The erosion was progressing upstream toward the main dam embankment, and it was felt necessary to make the appropriate changes before encroaching further on the dam.

The new spillway had not operated prior to the September 1979 field investigation.

Minor repair work on the outlet works conduit has been performed in recent years; in particular, holes in the pipe wall, and the entire pipe invert downstream of the control gate, have been grouted. The seriousness of the conduit

condition has been previously reported by Montana DNRC inspectors (Ref. 2), but only minimal repair has been afforded.

2.4.4 Warning System

There is no formal warning system or plan of action in the event of dam distress.

CHAPTER 3
FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the dam, supplemented by analysis of the project in accordance with the guidelines (Ref. 1) and the contract performance standards, resulted in the following findings.

3.1.1 Size, Hazard Classification and Safety Evaluation

In accordance with the inspection guidelines (Ref. 1), the Yellow Water Project is classified intermediate in size and has a high downstream hazard potential rating. The recommended spillway design flood for this project is 100 percent of the PMF. Because the project can safely handle only 10 percent of the PMF without overtopping and causing the dam to fail, and because of the severly deteriorated outlet conduit, the Yellow Water Project is considered unsafe-emergency until recommended actions are completed.

3.1.2 Spillway

The spillway system was designed to accommodate a relatively small flood event compared to current standards. The maximum existing spillway capacity, assuming the reservoir pool is at the first overtopping dike crest elevation, is approximately 3,500 cfs. The floodwater storage capability between the spillway crest and the first overtopping elevation amounts to 3,200 AF. In comparison, the PMF for the 55 square-mile drainage area is estimated to have a peak runoff value of about 118,900 cfs and a total runoff volume of about 67,300 AF. Hence, the combination of reservoir storage and spillway discharge capabilities is considered seriously inadequate in preventing overtopping of the dam and dike during the PMF.

The spillway is presently in good physical condition as it has not been called upon to operate. The bed slope along the spillway channel is very irregular; in fact, it is essentially constructed on a horizontal grade from inlet to outlet (Sheet 4, Exhibit D1). Recommended minimal improvements for the spillway include regrading of the channel invert, and stabilizing the channel bed and bank material. As a major improvement, the spillway needs to be enlarged.

3.1.3 Outlet Works

The outlet works approach channel, inlet structure, and conduit from the inlet to the control gate were not inspected due to the reservoir pool level. Inspection was made of the downstream side of the control gate, the lower reach of conduit, the outlet structure, and return channel.

Leakage was observed around the gate, particularly at the pipe crown. Hence, repairs are needed at the gate seat.

The outlet works conduit is a 42-inch diameter corrugated steel pipe. Past repair efforts concentrated on the severe corrosion/erosion along the pipe invert, and on isolated holes in the conduit wall. Severe pipe deterioration was reported by Montana DNRC inspectors as early as October 1972 (Ref. 2). Historical rehabilitation basically consisted of grouting the problem areas. Some of the grout material has been eroded out of place, and the severely deteriorated pipe sections are again exposed. In particular, a large portion of the grout material has been removed by erosion immediately downstream of the gate. It is possible to feel the earth and gravel foundation below the pipe where the grout section has been removed. Even above the normal flow line the metal surface shows evidence of significant corrosion. One of the largest holes in the sidewall, located 18 inches from the outlet, has been grouted (Photo 19). An inward bulge in the pipe wall and a depression along the pipe crown were observed 80 feet and 85 feet upstream of the outlet, respectively. The hydraulic conveyance of the facility is reduced by the scattered rocks located along the pipe invert.

The mortar binder for the rock sidewalls of the outlet works structure has deteriorated, and rocks are dropping from the sidewalls into the stilling area (Photo 18). Bank erosion is evident immediately downstream of the outlet structure.

The side slopes of the downstream irrigation canal have subsided, but appear to be presently stable with an adequate vegetative cover (Photo 17).

3.1.4 Dam

The Yellow Water embankments appear to be stable and in good condition, except for the oversteepened areas on the upstream face of the main embankment. Some questions exist as to the factor of safety against slope instability because stability analyses are not available for review and soil strength and piezometric conditions are unknown. Seepage is occurring through the dam and abutments, however, there are no indications of seepage related problems other than that associated with the holes in the outlet conduit. There are some rather large bushes located on the upstream face of the main dam embankment which should be removed. An erosion gully was noted along the left abutment contact on the upstream side of the main dam. There are depressions and ruts along the main dam crest and the dike crest (Photo 21 and Exhibit D2). Recommendations have been prepared accordingly.

3.1.5 Geology

The geologic investigation for this report was based on the subsurface profile drawing, regional geology reports, and a surficial field investigation. Limited drill hole information was available for review (Sheet 2, Exhibit D1). The reservoir basin is formed in a sandy shale sequence with sandstone beds forming ledges throughout the area. The valley section at the damsite consists of alluvial deposits of sandy and silty clays. No major stability or foundation problems were noted. The Yellow Water Storage Project is located in a relatively quiet seismic area.

3.1.6 Operation and Maintenance

There are no formal operation plans and/or maintenance programs for the Yellow Water Storage Project. The dams are visited regularly throughout most of the year by the ditch rider and/or water commissioner to regulate water releases. Regular project inspections are performed jointly by the DNRC and representatives of the local water users' association. Some repair work has been accomplished in the past, but not all project components have been maintained or repaired when first required. The basic reason for the meager maintenance program and repair efforts is the ever-present manpower and budgetary limitation. A warning system to alert downstream inhabitants of dam distress has not been developed.

3.2 RECOMMENDATIONS

(1) Immediately develop, implement, and periodically test an emergency warning plan for use in the event of dam distress.

(2) Immediately lower the reservoir, inspect the entire outlet facility, and repair or replace the deteriorated conduit and other components. Specific repairs required on the outlet works facility, in addition to the conduit, include the repair of the control gate seat and repair of the outlet structure sidewalls. Observe caution when using the outlet works, whether it be during normal operation, during passage of flood flows, or during the lowering of the pool, so as not to accelerate the deteriorating condition of the conduit. It is recommended that lowering of the pool be performed under the direction of a qualified engineer. The inspection and replacement/repairs need to be accomplished prior to raising the pool.

(3) Install piezometers in the main dam, foundation and abutments, and establish a regular long-term monitoring program for the piezometers and for monitoring the seepage areas identified in the report. Monitor closely during periods when the reservoir pool is relatively high.

(4) Replace/rearrange rock riprap in the following areas: along the upstream face where the embankment has eroded and the rock has moved downslope, and in the outlet works stilling area.

(5) Repair the erosion gully along the left abutment contact on the upstream side of the dam.

(6) Remove or kill bushes on the upstream face.

(7) Fill and regrade all depressions and ruts along the crests of the main dam and the dike.

(8) Regrade the spillway to provide positive drainage and to improve the hydraulic capabilities. Protect the channel side slope and bed materials from erosion by vegetating or other means.

The above recommendations will not make the project safe but will reduce involved risks while the following recommendations with subsequent actions are being accomplished.

(9) Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazards and required spillway capacity. Modify project as studies indicate.

(10) Conduct and place on file, stability and seepage analyses of the main dam embankment. It is recommended these analyses be performed by a qualified geotechnical engineer and be based on: static loading conditions; in situ strength properties of the embankment, foundation, and abutment materials; and phreatic surface conditions. Establish the material strength properties by drilling and sampling with laboratory testing as appropriate; and obtain the phreatic surface by installing and monitoring piezometers. Modify project as studies indicate to insure conformance with inspection guidelines stability criteria.

(11) Conduct periodic inspections by qualified engineers at least once every five years to determine whether there are any deficiencies in the condition of the project, to assess the adequacy and quality of maintenance, and to evaluate methods of operation.

(12) Develop and implement a periodic maintenance plan for the dam and apprutenant structures.

The project operator should contact the Montana DNRC, Dam Safety Section, prior to performing any remedial construction to insure compliance with all pertinent laws and regulations.

REFERENCES

1. U. S. Army Corps of Engineers, Office of the Chief of Engineers Report to the U.S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspection of Dams", Washington, D.C., Department of the Army, May 1975.

2. Montana Department of Natural Resources and Conservation, Water Resources Division, Yellow Water Dam, Inspection File, Inspection Reports, 1972, 1974-1976.

3. U.S. Geological Survey, Roundup, Montana, AMS, Scale 1:250,000, 1954 with limited revision 1965.

4. Montana Water Resources Board, Montana Register of Dams, Inventory Series No. 3, October, 1968.

5. U.S. Geological Survey, 7½-Minute Quad Maps, Petrolia Lake, Montana, 1963, Breed Spring, Montana, 1963, Mosby, Montana, 1962.

6. Montana Department of Natural Resources and Conservation, Water Resources Division, Progress Report: Project Critiques, Supplement "A", January 1973.

7. Montana Department of Natural Resources and Conservation, Water Resources Division, State Water Conservation Projects, March 1977.

8. Montana Department of Natural Resources and Conservation, Water Resources Division, Yellow Water Dam, Correspondence File.

9. Reeves, Frank, Geology of the Cat Creek and Devil's Basin Oil Fields and Adjacent Areas in Montana, USGS Bulletin 786-B, 1927.

10. Von Hake, C.A., Earthquake Information Bulletin, USGS, Vol. 10, No. 4, 1978.

11. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-2 Water Surface Profiles, Davis, California, June, 1973.

12. National Oceanic and Atmospheric Administration, Climates of the States, Volume II, "Western States Including Alaska and Hawaii", Port Washington, N. Y., 1974.

13. National Oceanic and Atmospheric Administration, Climatological Data, Montana, National Climatic Center, Asheville, N.C.

14. U. S. Bureau of Reclamation, Design of Small Dams, 2nd. Edition, 1973, Revised Reprint, 1974.

REFERENCES
(Continued)

15. Department of Planning and Economic Development, State of Montana, "Comprehensive Area-Wide Water and Sewer Plan, 1970, State of Montana, Petroleum, Garfield, and McCone Counties", 1971.

16. U.S. Geological Survey, Water Resources Data For Montana, - 1977.

17. U. S. Weather Bureau, Technical Paper No. 38, Generalized Estimates of Probable Maximum Precipitation for the United States West of the 105th Meridian for Areas to 400 Square Miles and Durations to 24 Hours, Washington, D.C., 1960.

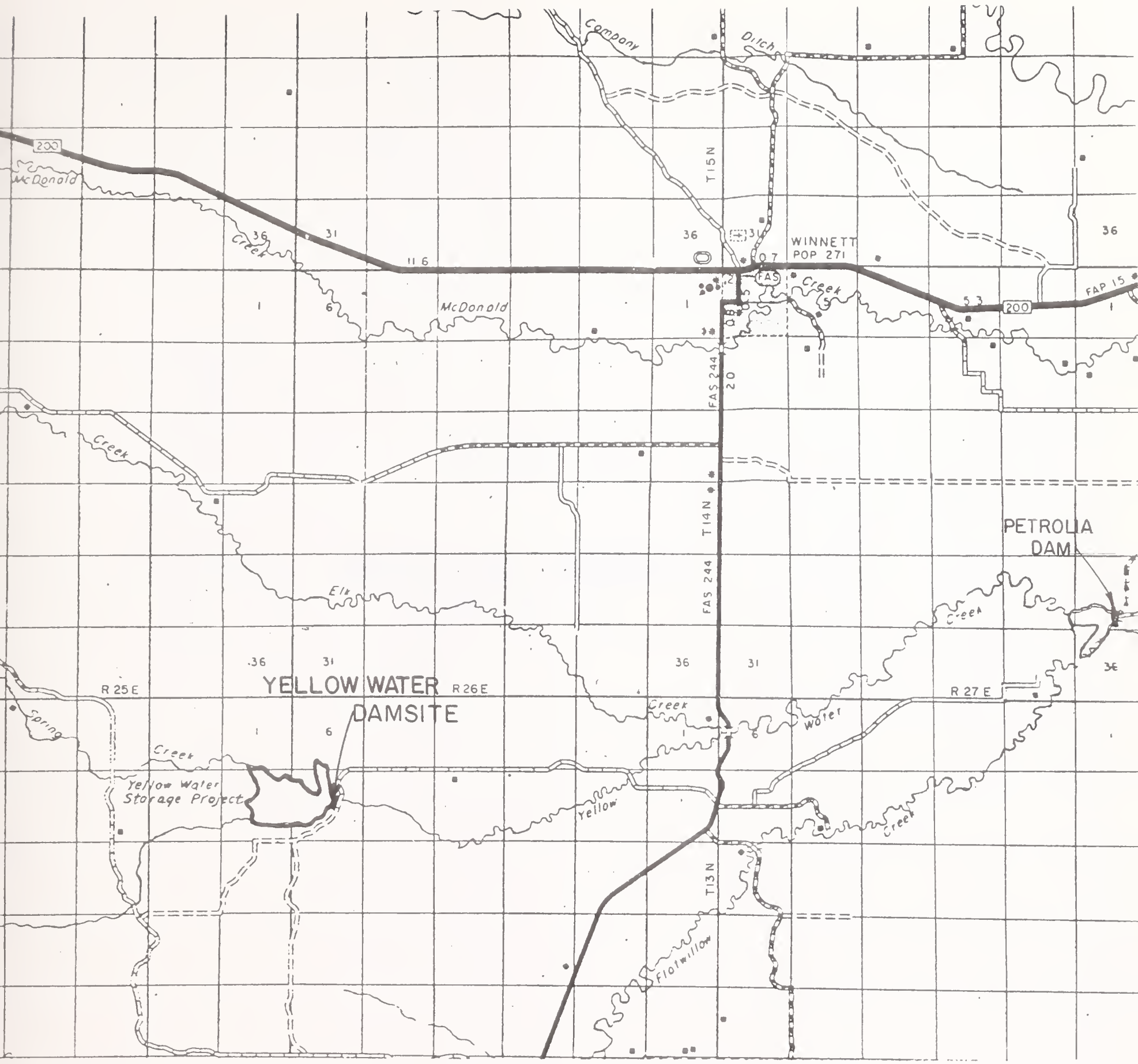
18. U.S. Weather Bureau, Hydrometeorological Report No. 43, Probable Maximum Precipitation, Northwest States, Washington, D.C., 1966.

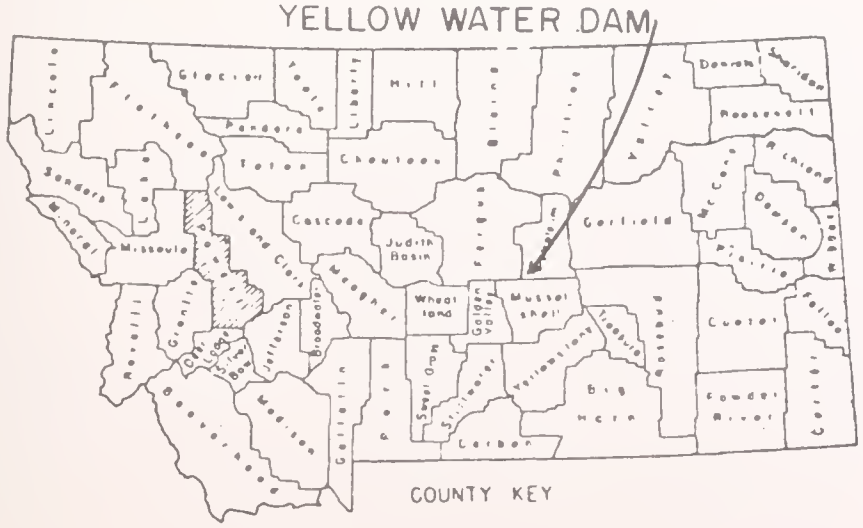
19. U.S. Soil Conservation Service, National Engineering Handbook, Section 4, "Hydrology", Washington, D.C., 1969.

20. U. S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package, Davis, California, September, 1978.

APPENDIX A

YELLOW WATER RESERVOIR
VICINITY MAP





N

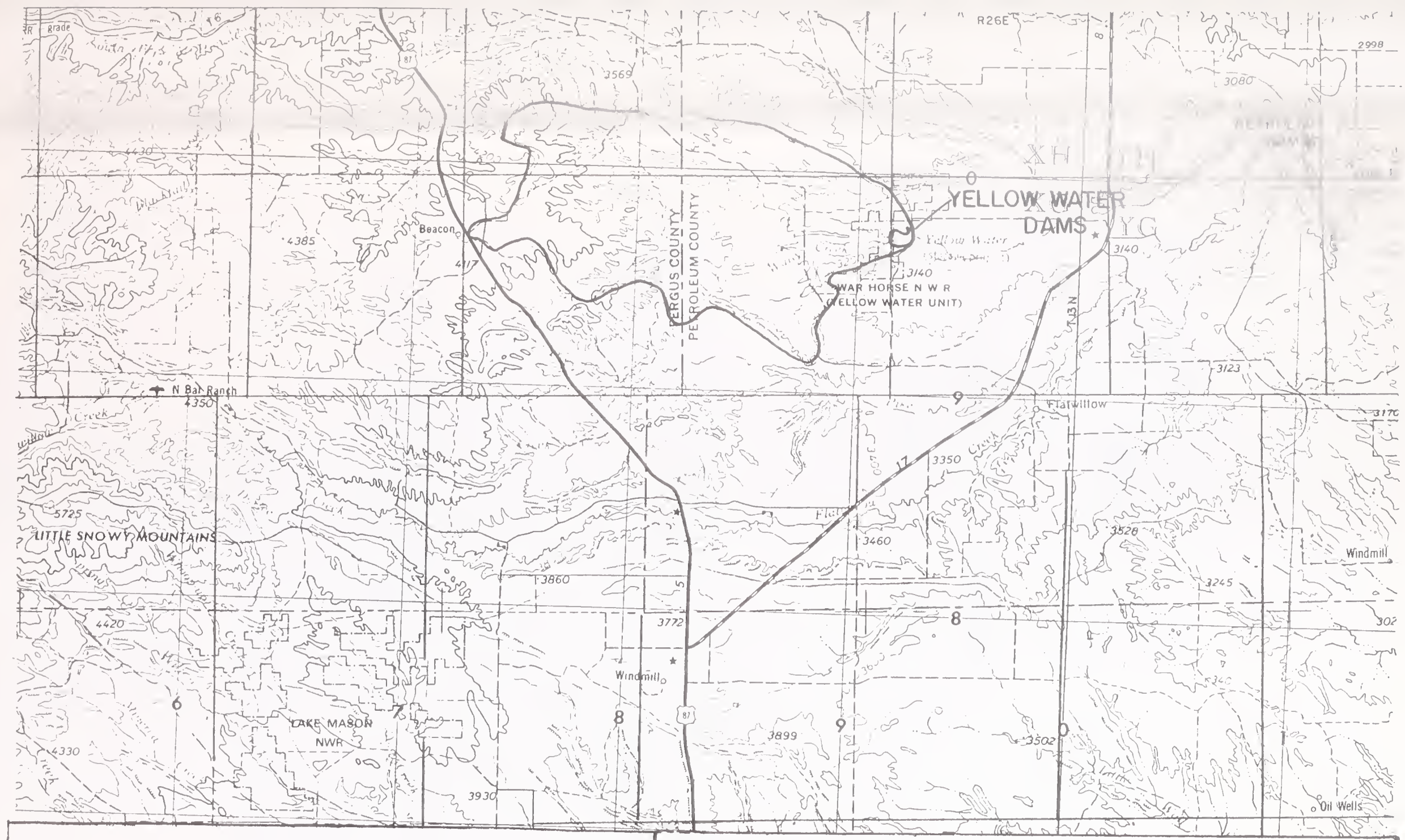
SCALE
1 0 1 2 3 4 MILES

SOURCE: GENERAL HIGHWAY MAP, (1973)
PETROLEUM COUNTY, MONTANA
MONTANA STATE HIGHWAY COMMISSION

APPENDIX A
VICINITY MAP
YELLOW WATER DAM

APPENDIX B

YELLOW WATER RESERVOIR
WATERSHED MAP



APPENDIX B
WATERSHED MAP
YELLOW WATER RESERVOIR

(EXCERPT FROM ROUNDUP AMS MAP, U.S.G.S.)

APPENDIX C

YELLOW WATER RESERVOIR

INSPECTION PHOTOS

NOTE: Photos cover Yellow Water Main Dam (MT 12) and Yellow Water Dike (MT 3205), even though only Dam MT 12 is referenced on every plate.

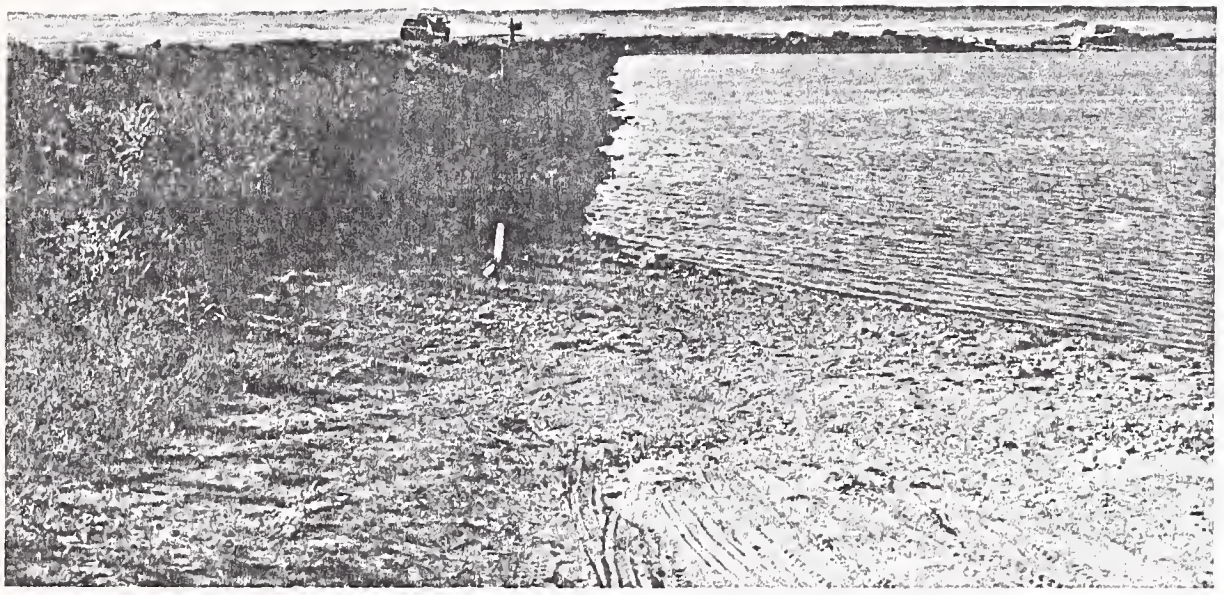


Photo No. 1 - Upstream face of Dam
Outlet works control tower and operator shown in photo center. Standing at the left abutment looking south. The 3 autos lined-up in the background are on the crest of the main dam near the spillway entrance.

Photo No. 2 - Upstream Face of Dam
Looking north toward the left abutment. Notice the riprap thins in the foreground where the natural soil is exposed. This photo shows the main embankment.

Photo No. 3 - Upstream Face and Dam Crest
The crest of the embankment turns to the southwest near this point, then again to the south near the 3 autos (see also Photo No. 1). The tops of several campers and trailers are visible. These vehicles are parked in the spillway.

Photo No. 4 - Downstream Face of Dam
Looking south along the main embankment. There is a berm located about 2/3 of the way down the slope. Notice the vegetative cover. Also note water ponding downstream of the dam embankment.

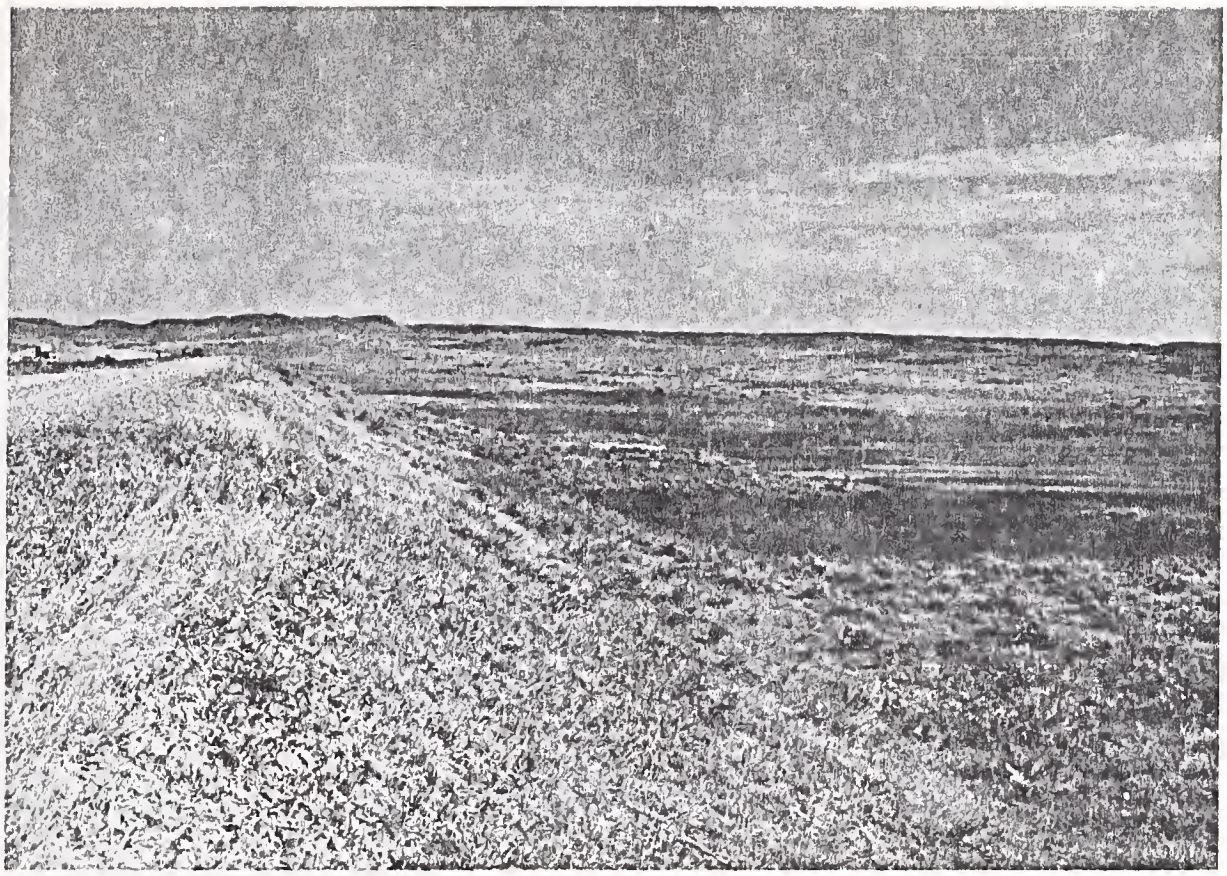


Photo No. 5 - Downstream Face of Dam
Looking north toward the left abutment. There is a moderate vegetative cover of natural grass, weeds, and sagebrush on the downstream slope. Source for ponding water is seepage and water from the low-level outlet return channel.

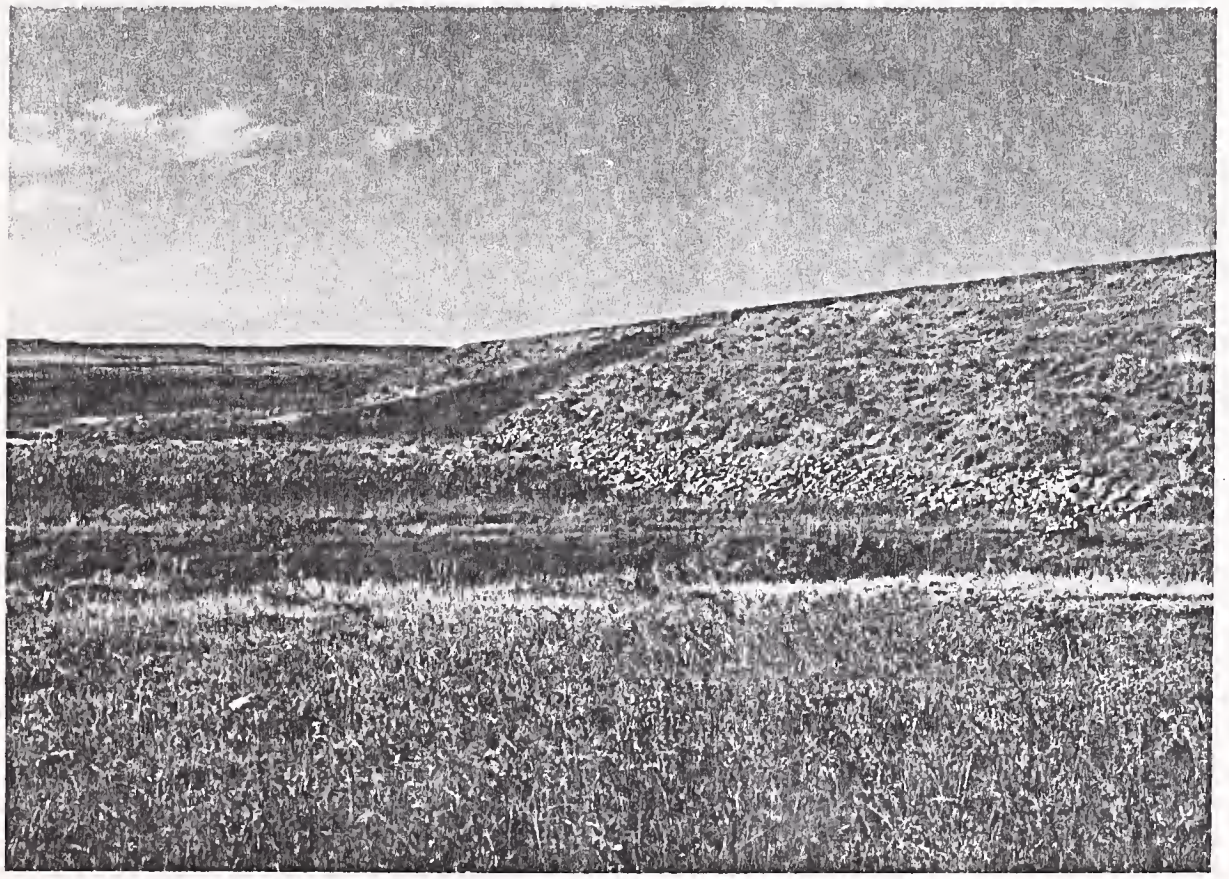


Photo No. 6 - Dam Embankment
The rock toe is visible at the base of the embankment. Outlet works return channel is located in the center of photo, running from photo edge to edge.

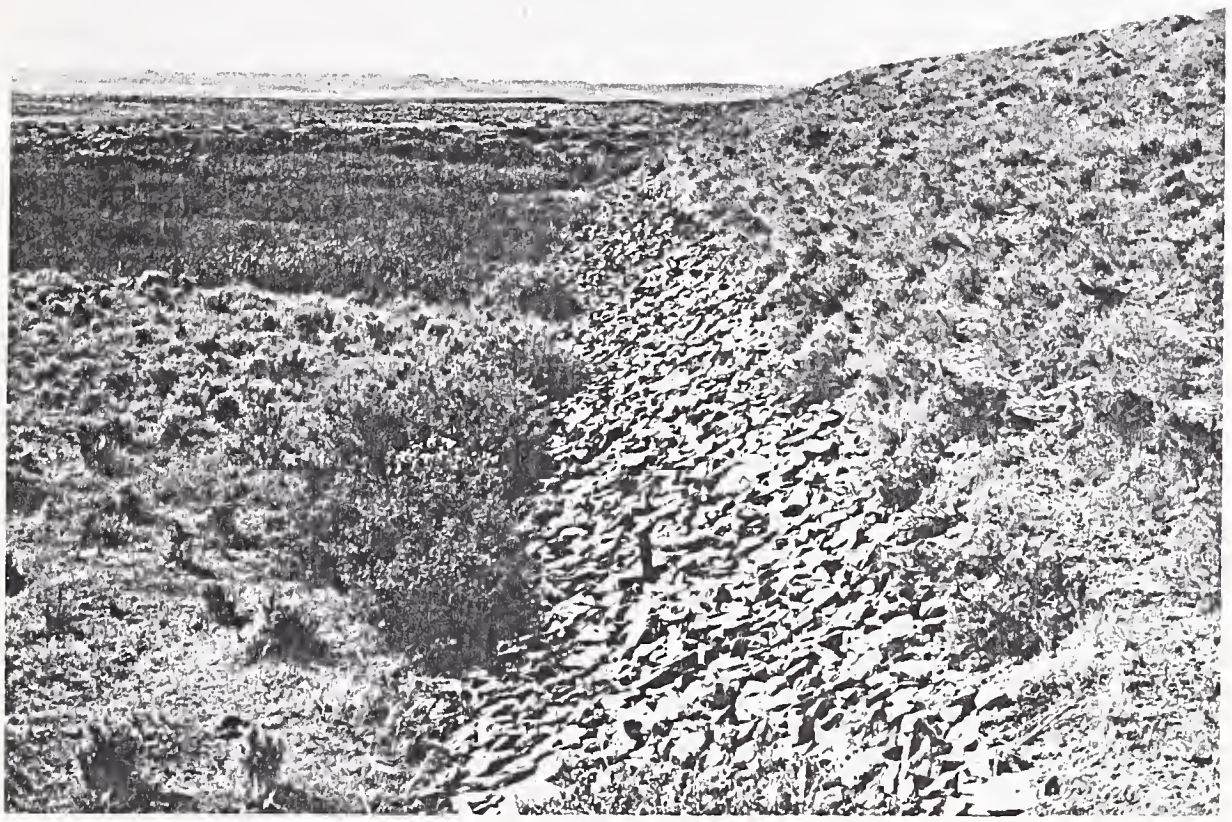


Photo No. 7 - Rock Toe of Embankment
There is a rock toe at the base of the main embankment. This material is very coarse and erosion resistant. Water is exiting from this material at several locations. See also Photo No. 28.

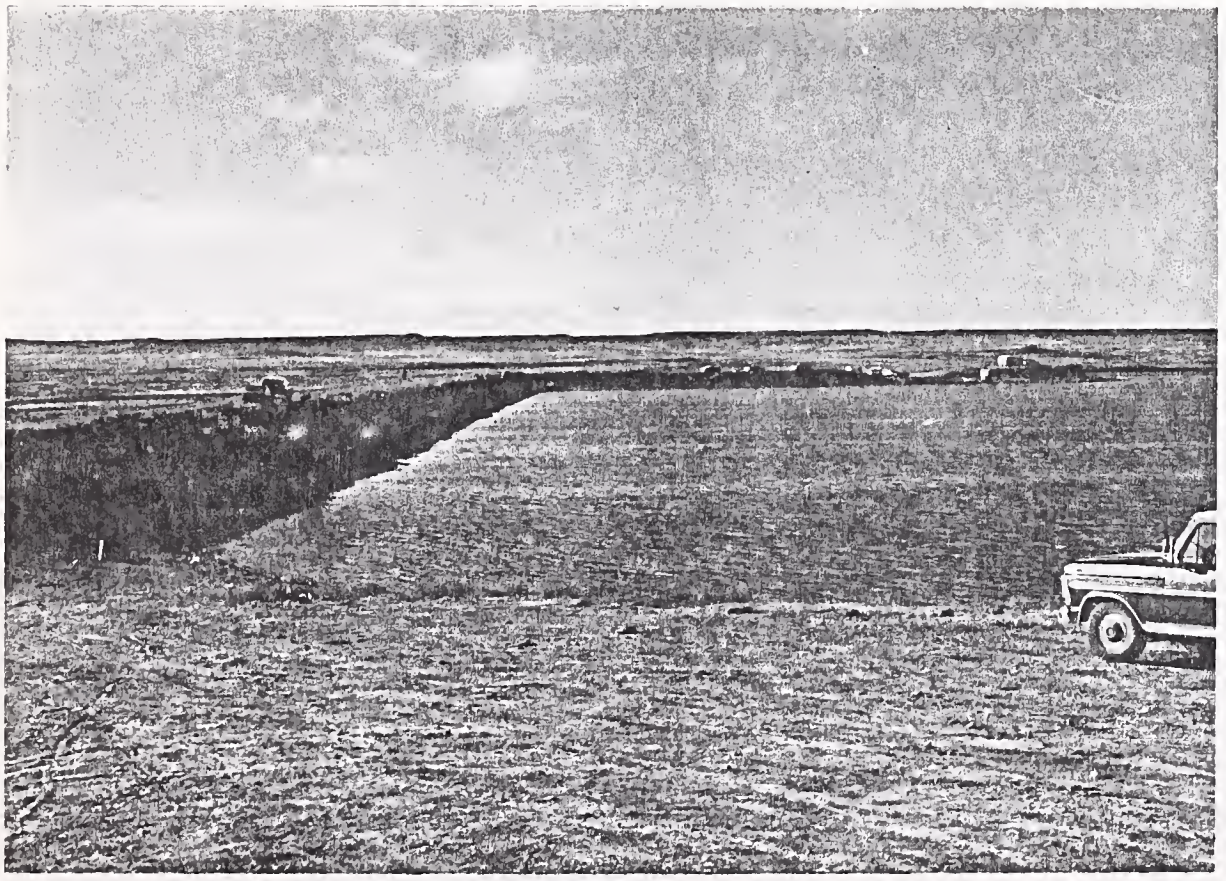


Photo No. 8 - Reservoir Basin and Shorelines
First in a 3-picture series. Standing on left (north) side looking south along dam. Similar to Photo No. 1.

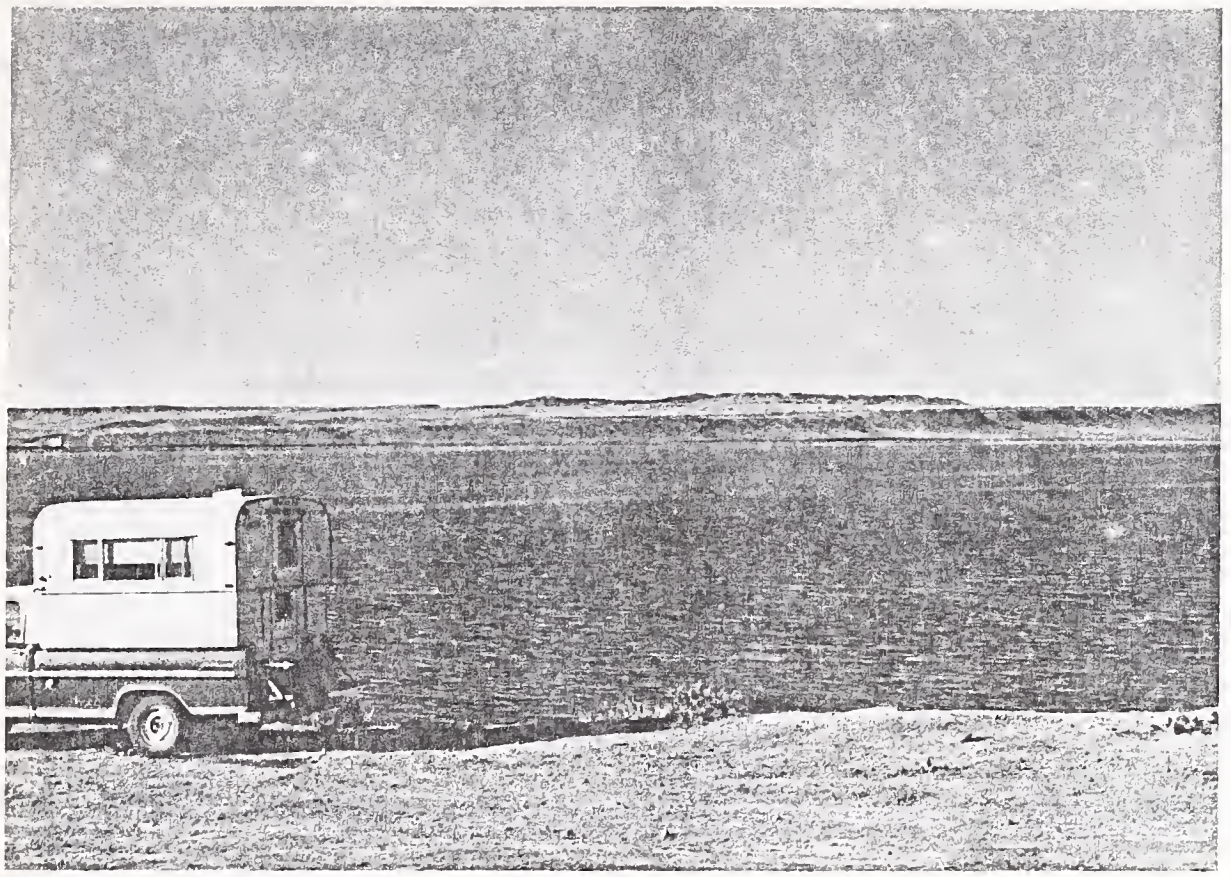


Photo No. 9 - Reservoir Basin and Shorelines
Second in a 3-picture series. Standing on left side looking at south shoreline.

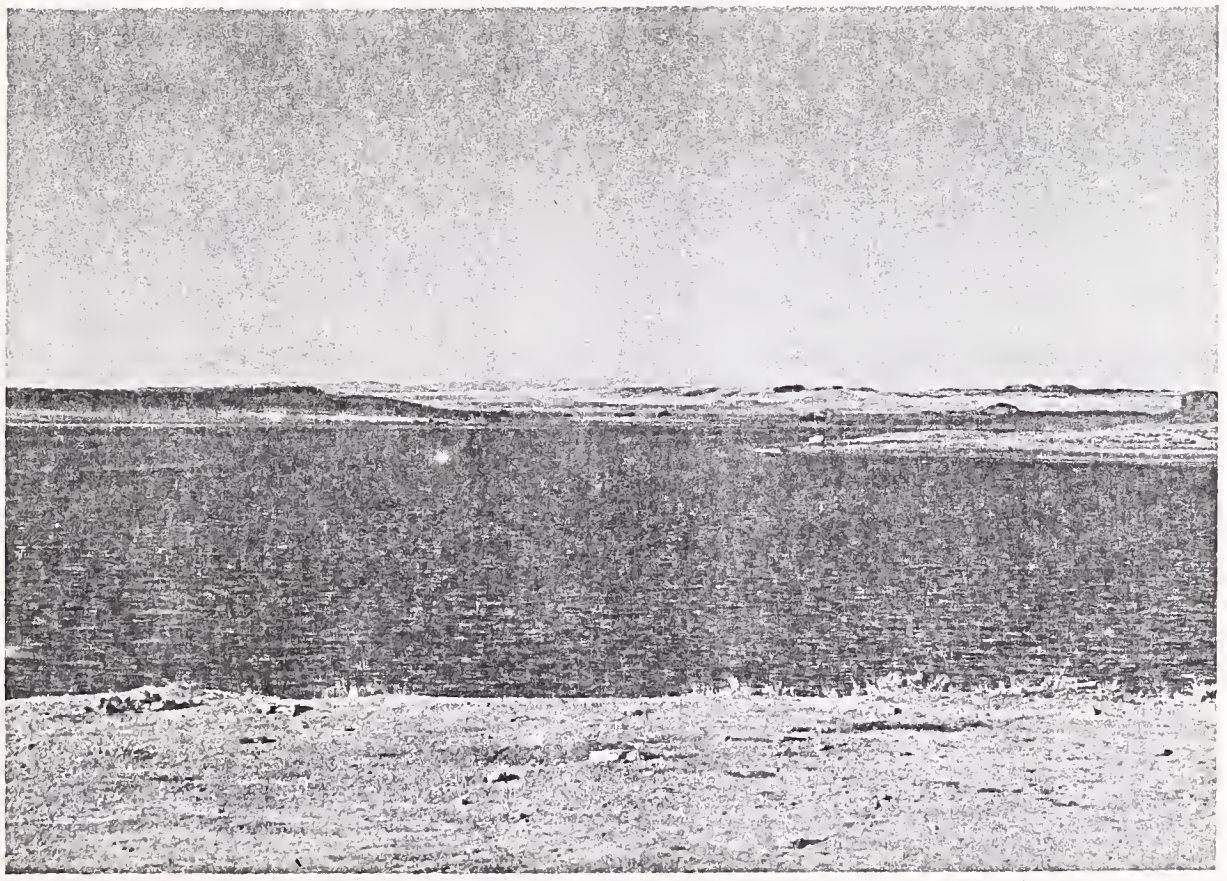


Photo No. 10 - Reservoir Basin and Shorelines
Third in a 3-picture series. Notice the local terrain is flat and rolling, and vegetated primarily with natural grasses.

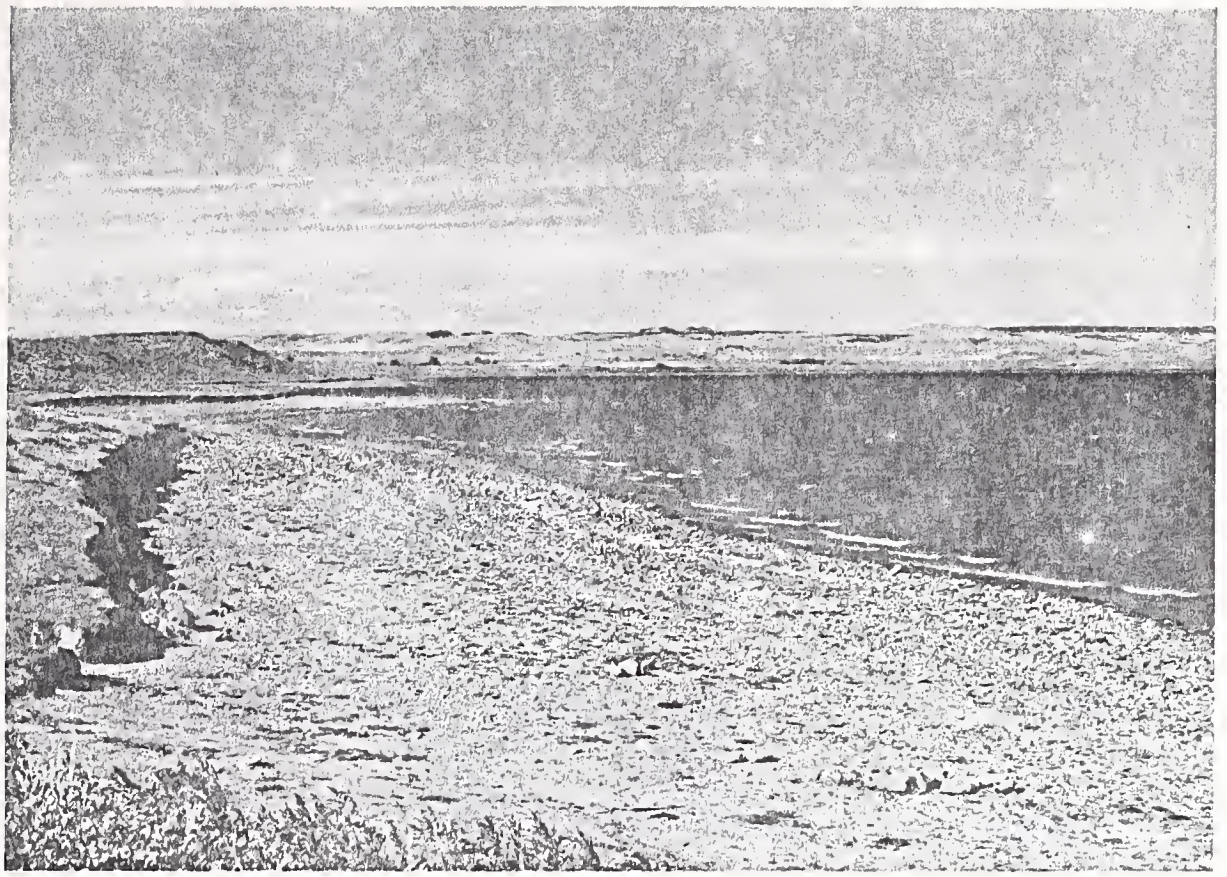


Photo No. 11 - South Shoreline
Local drainage basin can be seen in the background.
Notice the cutting action of the water at high pool.

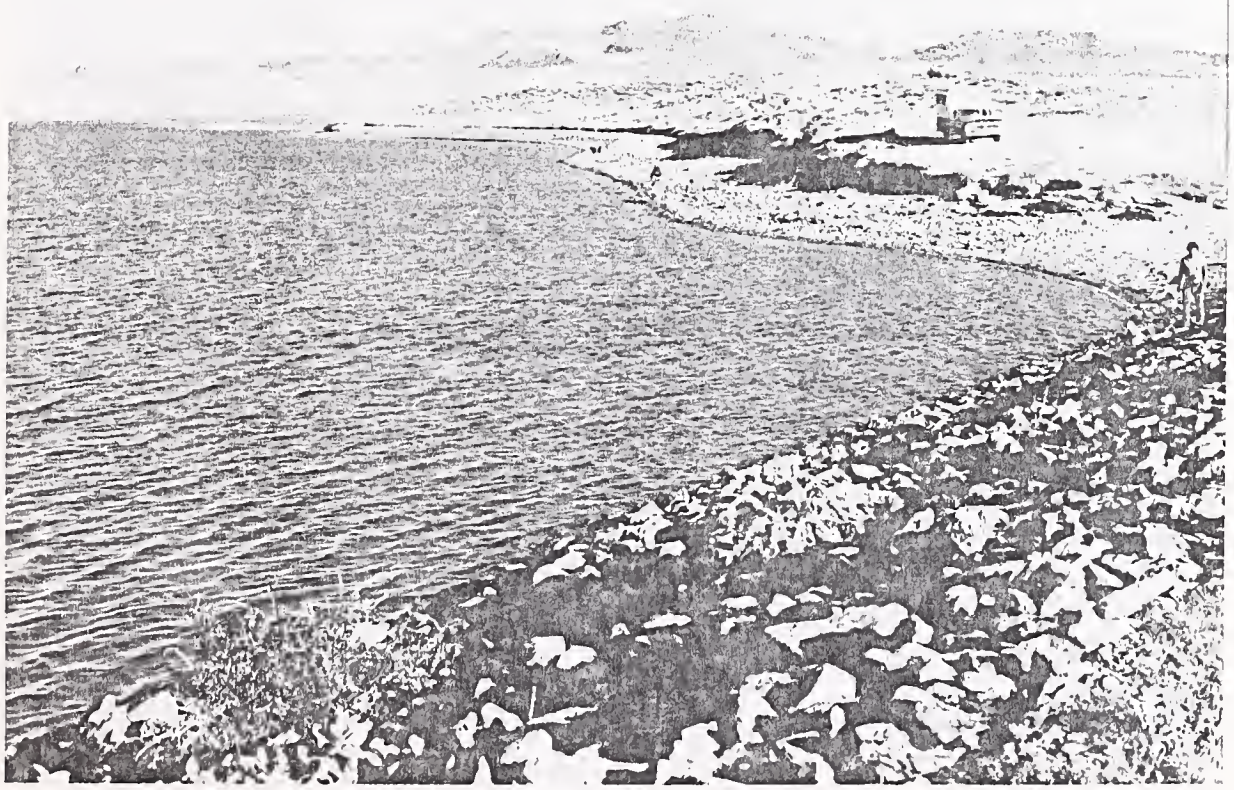


Photo No. 12 - North Shoreline
Notice the vegetative growth on the riprap face of the embankment. Also notice areas of vertical bank cutting along shoreline.

Photo No. 13 - Downstream Valley
The valley is shallow and broad. Vegetation consists of natural grasses and sagebrush. There are no farmsteads visible from the dam.

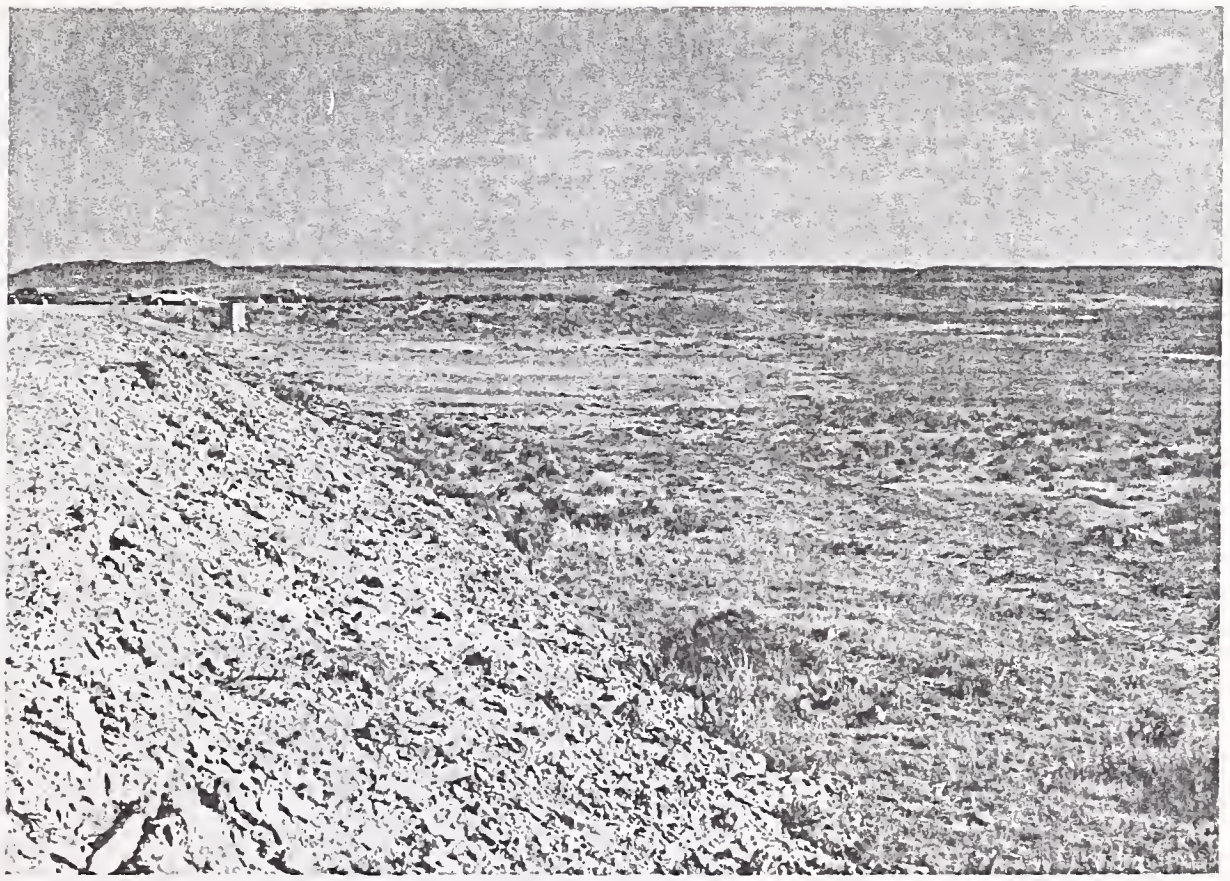


Photo No. 14 - Downstream Valley
First in a 2-picture series. Looking north along the downstream face of the new embankment spur. This spur forms the left (east) channel bank of the spillway. Notice the lack of vegetation on the face of the new embankment. Notice the 3 autos (see Photo No. 1).

Photo No. 15 - Downstream Valley
Second in a 2-picture series.

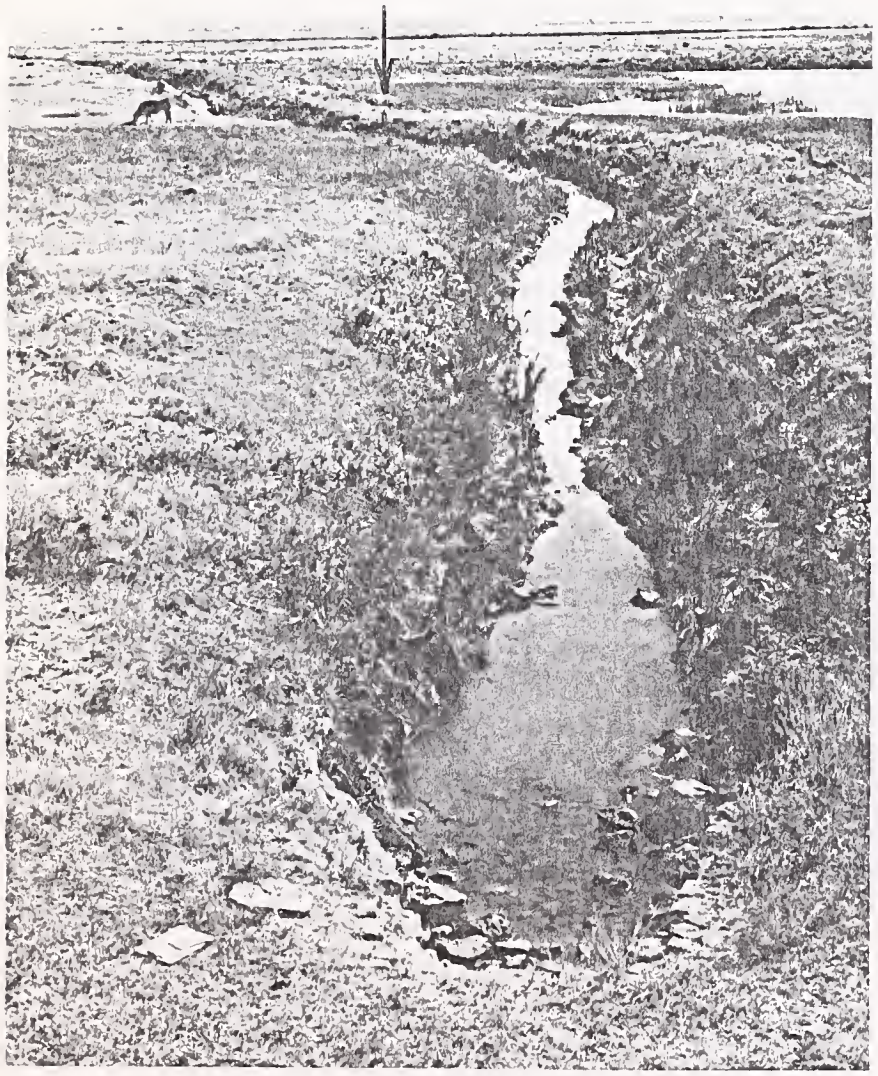


Photo No. 16 - Outlet Works
Return Channel

Looking downstream from the embankment. Notice the diversion structure (see arrow) which allows water to enter the pond in the upper right of the photo.

Photo No. 17 - Outlet Works Return Channel
The outlet diversion conduit serves as the low-level outlet for the dam.

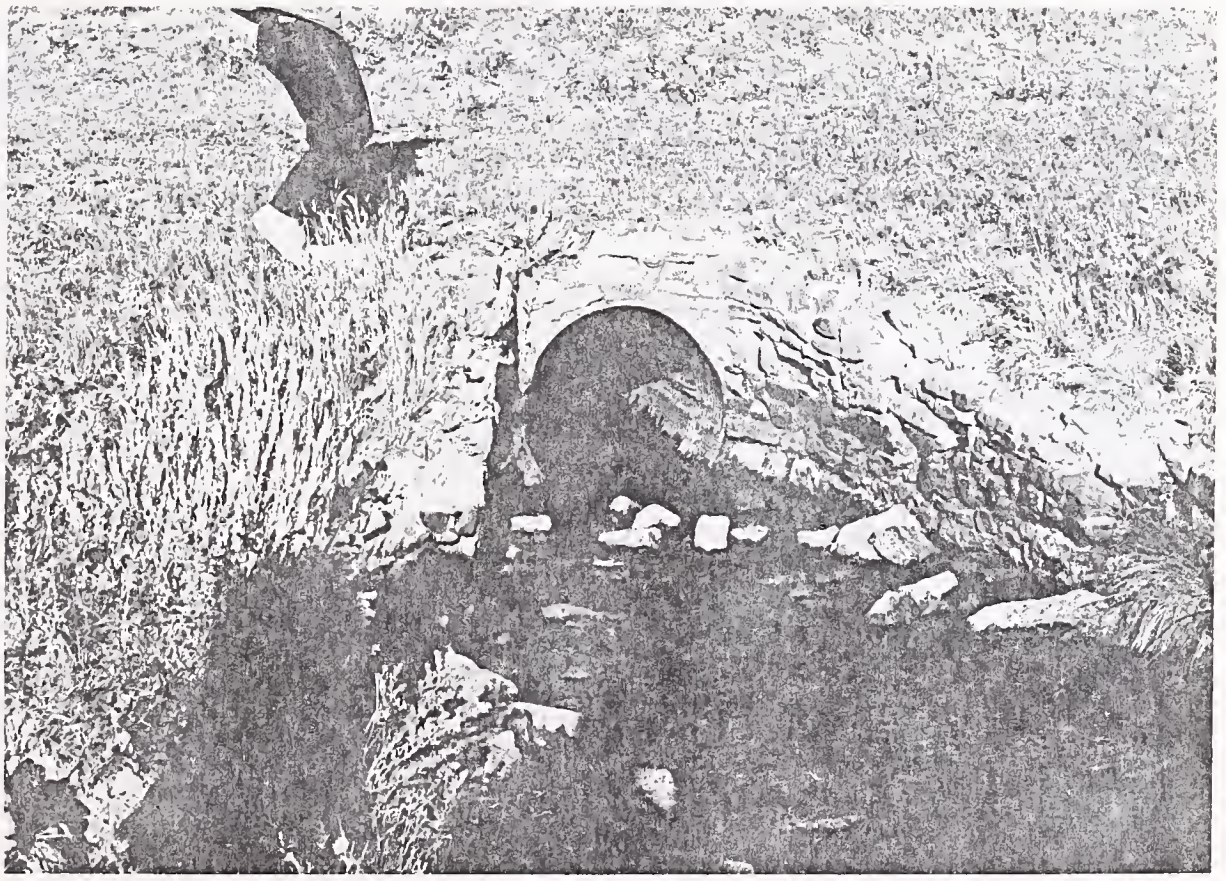


Photo No. 18 - Outlet Conduit and Structure
The outlet channel immediately below the outlet is constructed of sandstone inlaid in mortar. Notice the riprap in the bottom of the channel. Conduit is a 42-inch corrugated metal pipe.

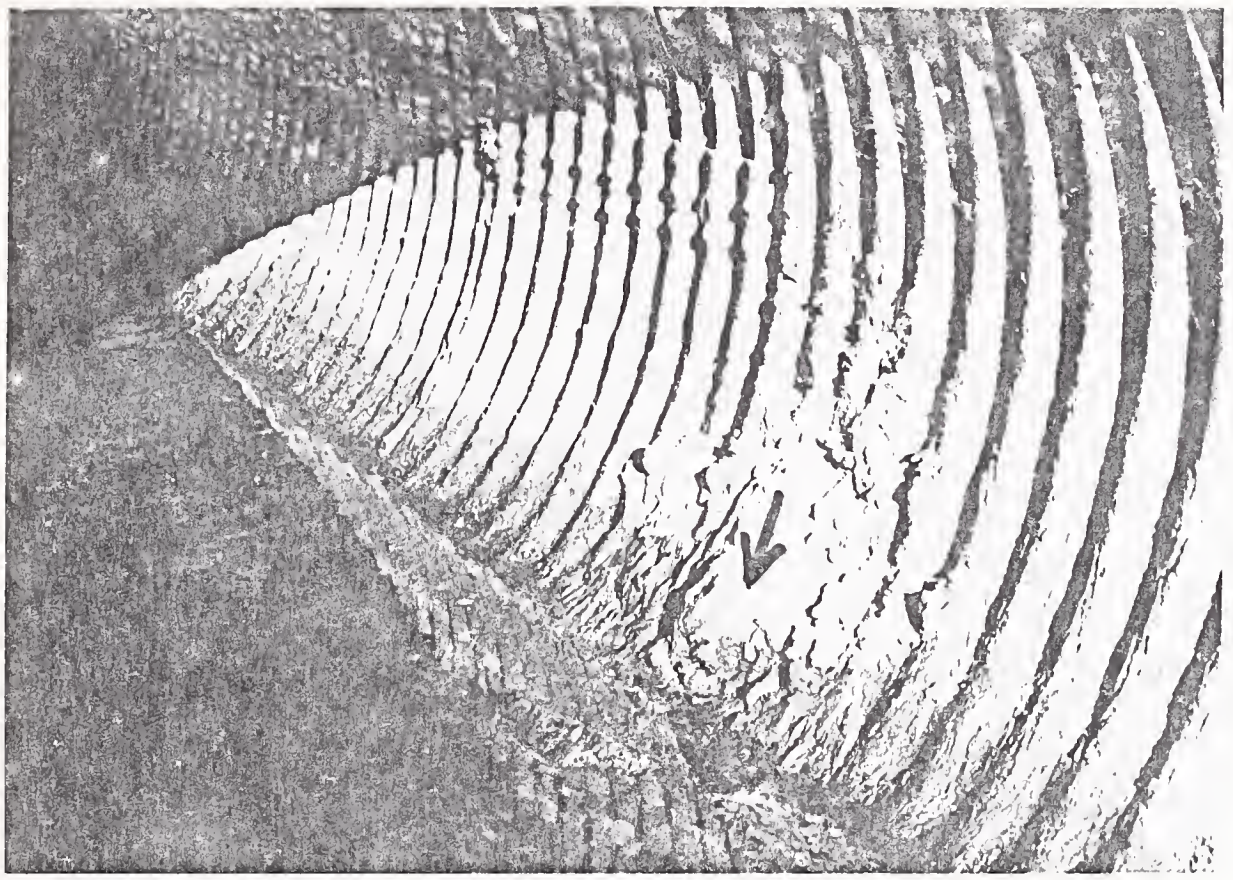


Photo No. 19 - Outlet Conduit
This photo shows a location where a hole has been made in the pipe, then grout was pumped in behind the pipe (see arrow). Notice the corrugated metal pipe is badly deteriorated. The bituminous coating is almost completely weathered and eroded off of the conduit.

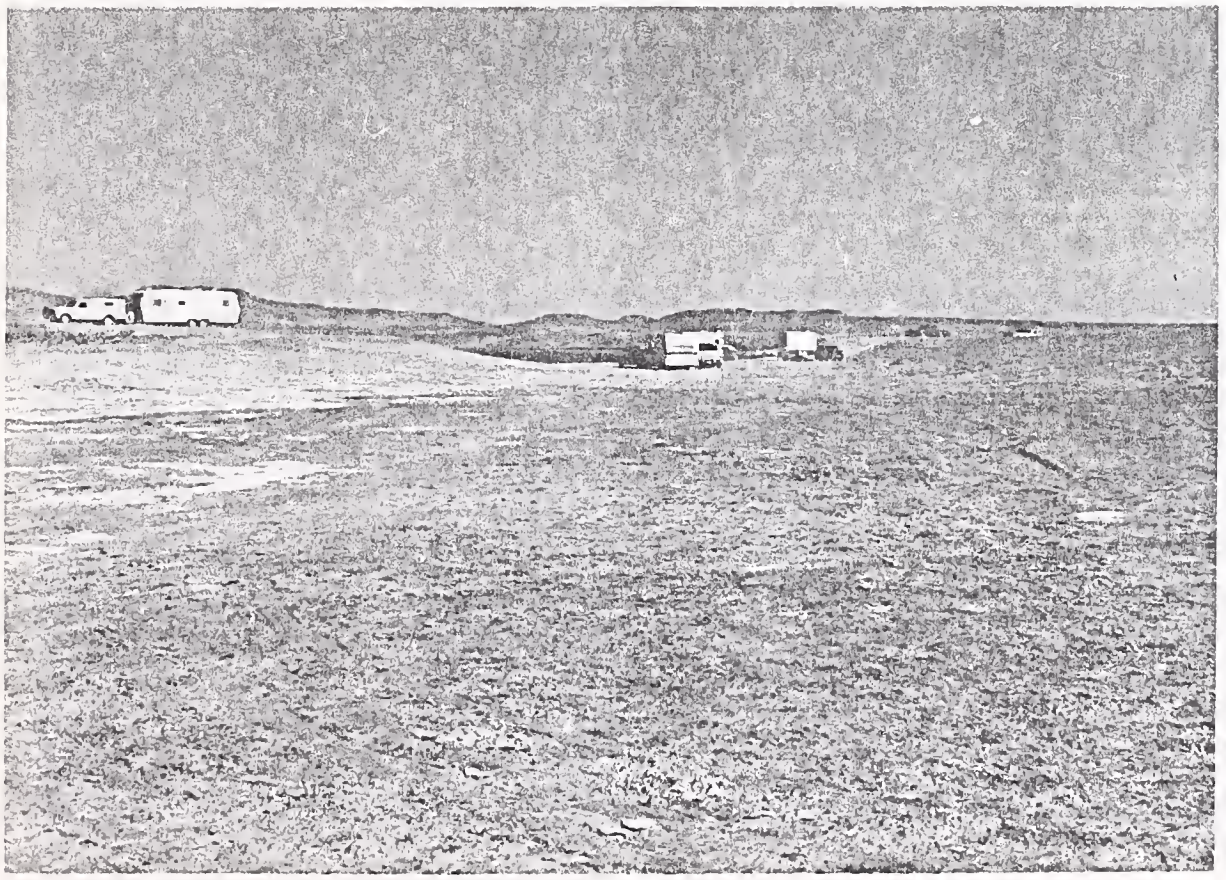


Photo No. 20 - Spillway
This photo was taken from the center of the spillway looking north toward the reservoir.

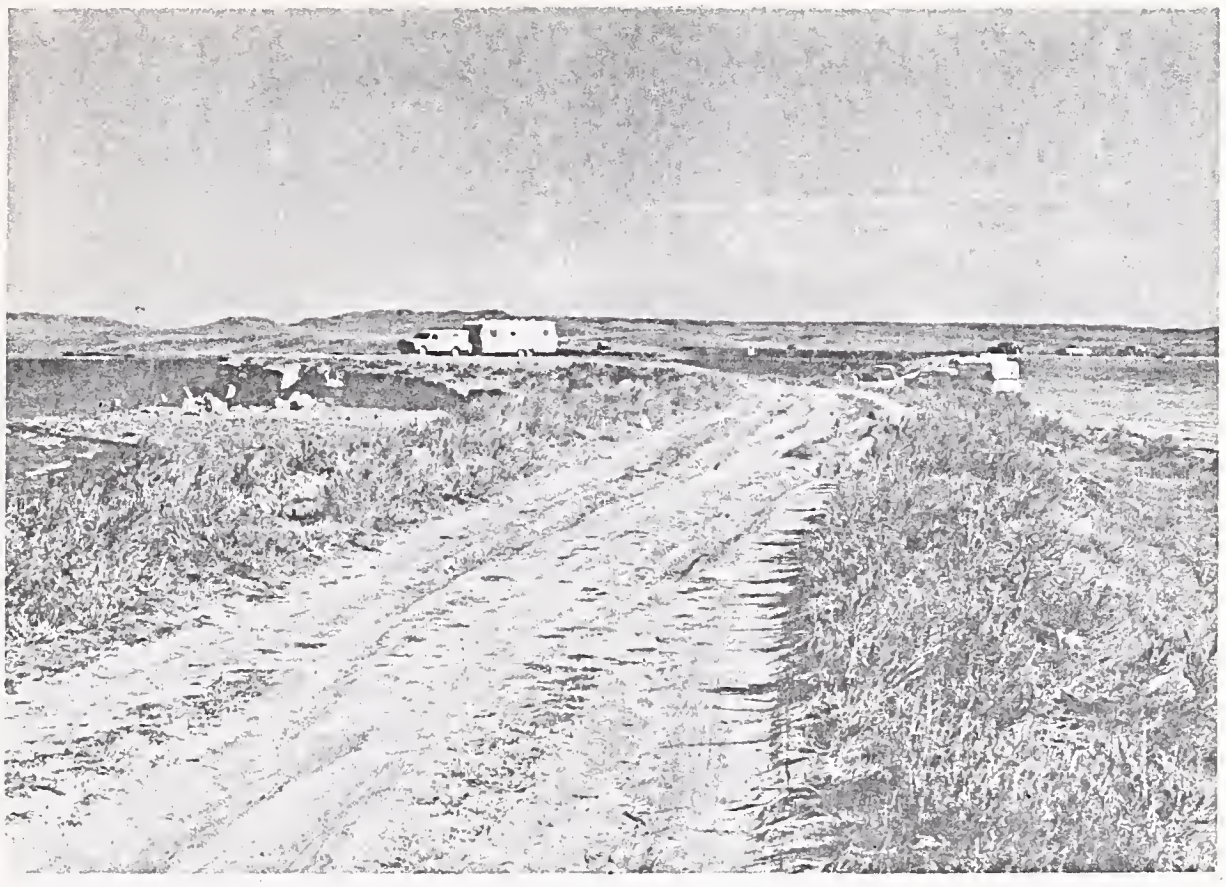


Photo No. 21 - Right Bank of Spillway and Spur Dike
Looking north along the top of the right bank of the spillway. This is also the spur dike for the dam. The spillway is visible on the far right of the photo.

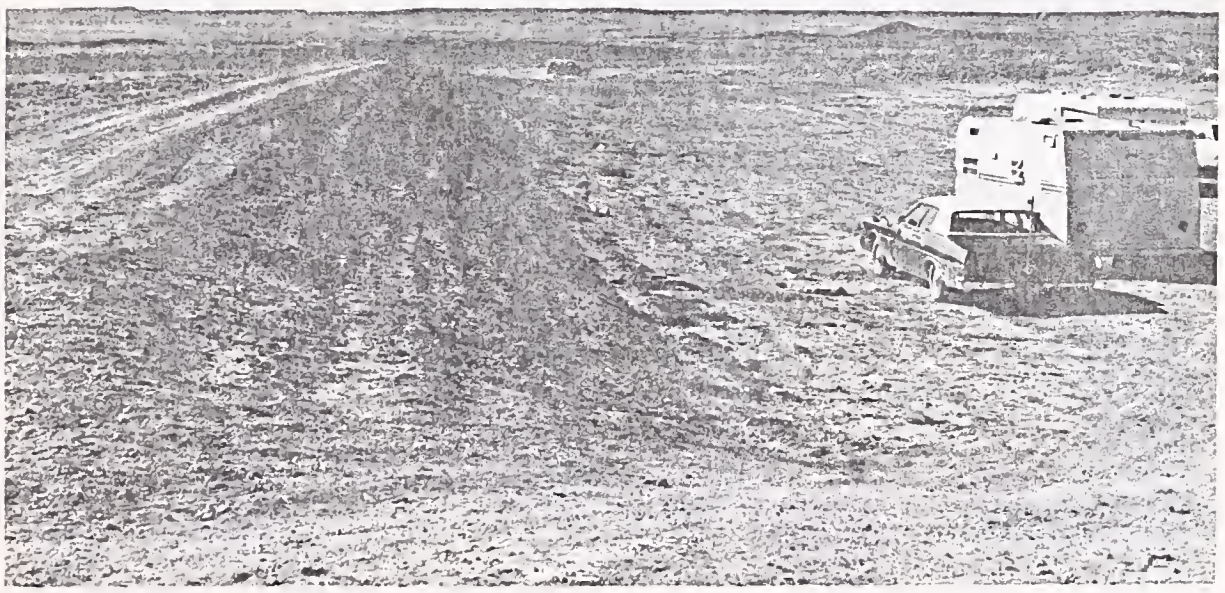


Photo No. 22 - Left Bank of the Spillway
Looking south along the upstream side of the new embankment spur. The vehicles in this photo are in the spillway channel.

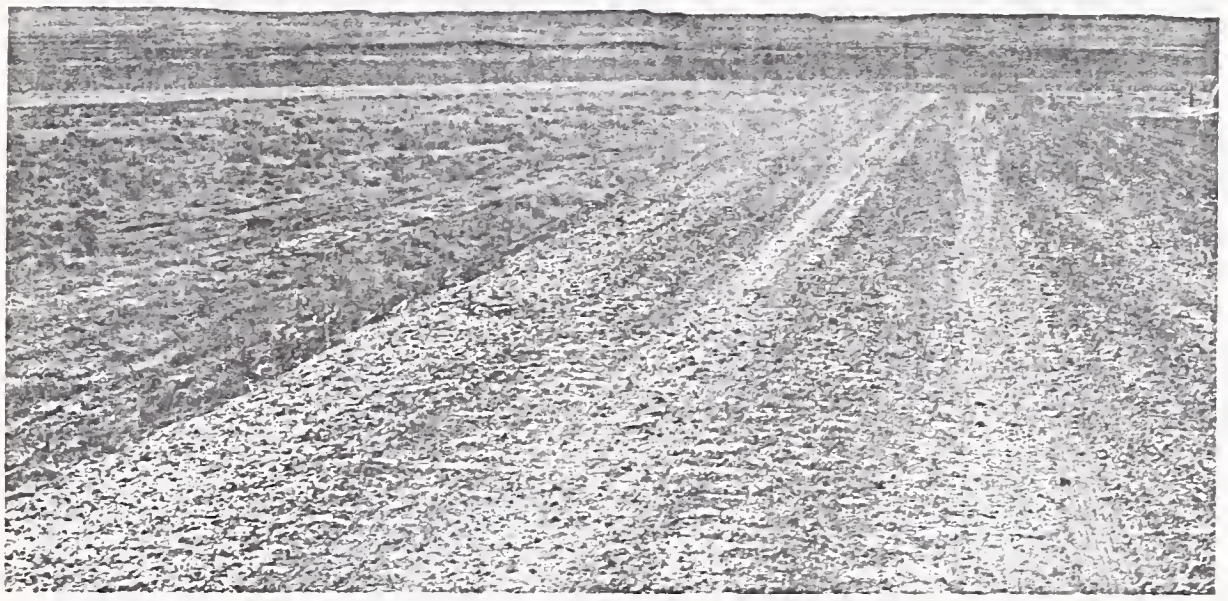


Photo No. 23 - New Embankment Spur
The foreground is the crest of the new embankment spur.
The background is the area downstream of the spillway.

Photo No. 24 - Rock Riprap
The riprap is located on the upstream face of the dam.
It is sandstone with a mean size of about 12 to 14 inches.
This material is in good condition.

Photo No. 25 - Rock Riprap
In some places the riprap protection has slid down the face leaving the embankment exposed.

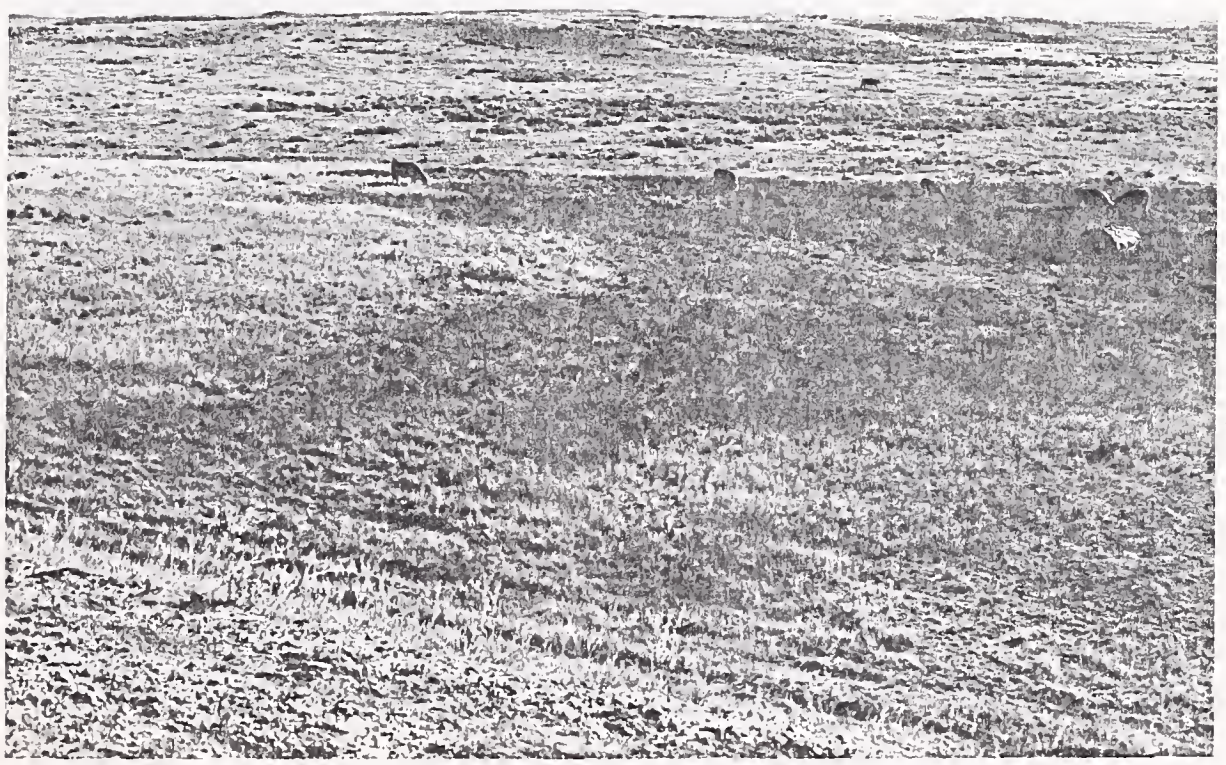


Photo No. 26 - Seepage on the Left Abutment
On the left abutment the groundwater appears high. This green patch of grass suggests seepage through the abutment is keeping the area wet.

Photo No. 27 - Springs Downstream
Numerous springs are evident downstream. The seepage appears to be running along the surface of the bedrock shale and exiting where the bedrock is exposed.

Photo No. 28 - Seepage
Numerous springs are exiting at the downstream rock toe. The toe drain is designed to carry seepage. These springs do not pose a stability problem.

APPENDIX D

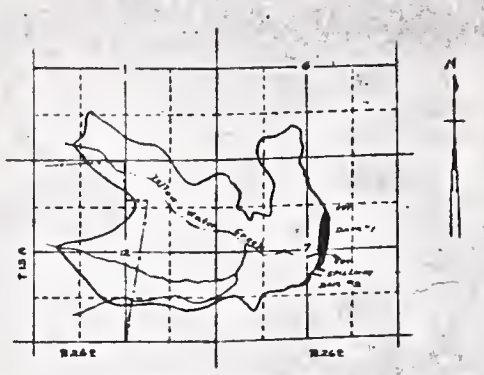
YELLOW WATER RESERVOIR

PROJECT DRAWINGS

EXHIBIT D1	CONSTRUCTION PLANS
EXHIBIT D2	DAM CREST PROFILE (OCT.1979)
EXHIBIT D3	MEASURED EMBANKMENT SLOPES (SEPT. 1979)

RESERVOIR CAPACITIES

Contour	Area Acres	Storage (Ac Ft.)
65	0	
70	24.2	60.5
75	67.0	288.0
80	143.1	813.0
85	219.7	1707.5
90	307.3	3262.5
OLD SPILLWAY CREST 92	373.9	4292.0
95	573.9	5715.5
1000	729.0	8478.5

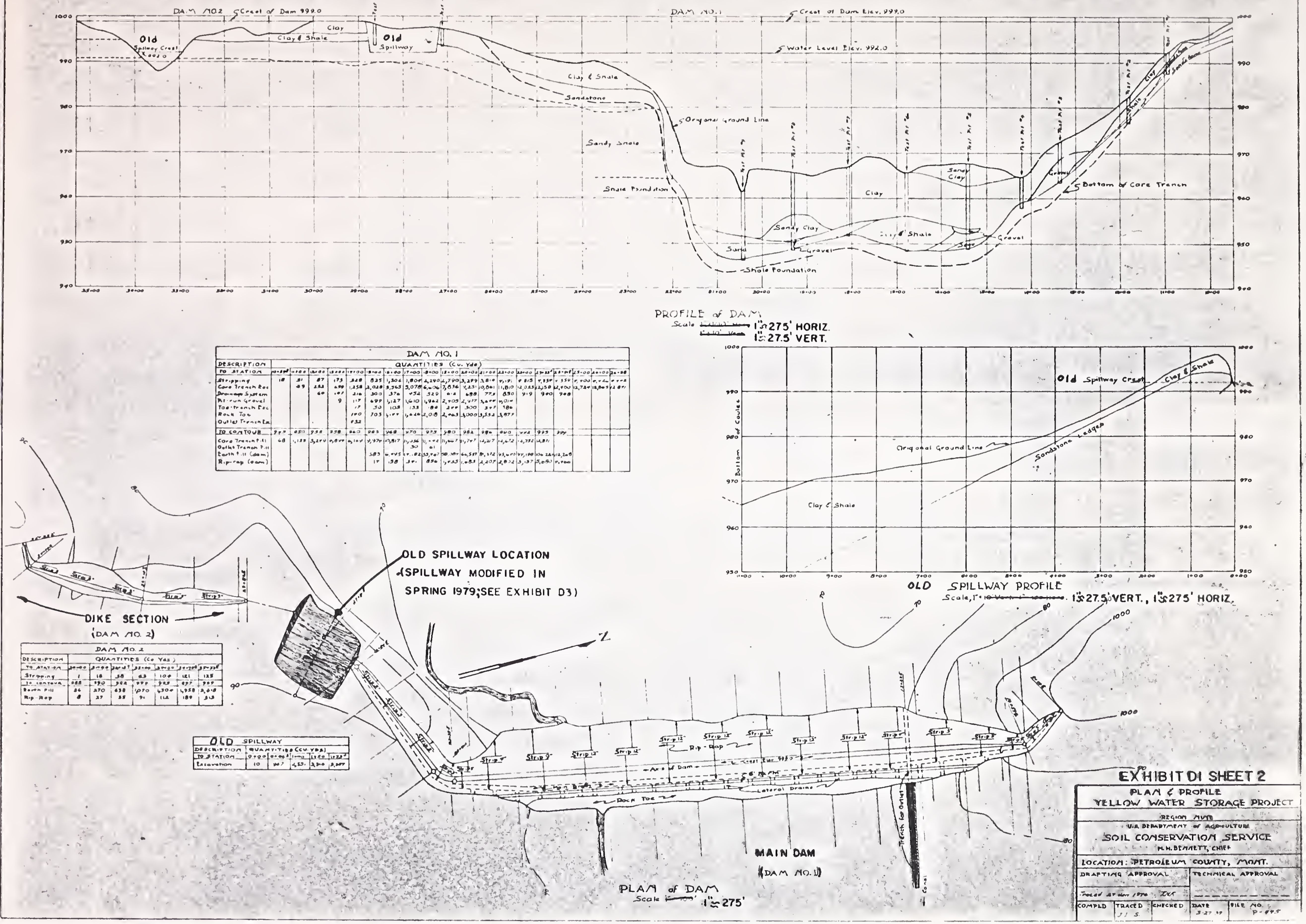


LOCATION MAP.

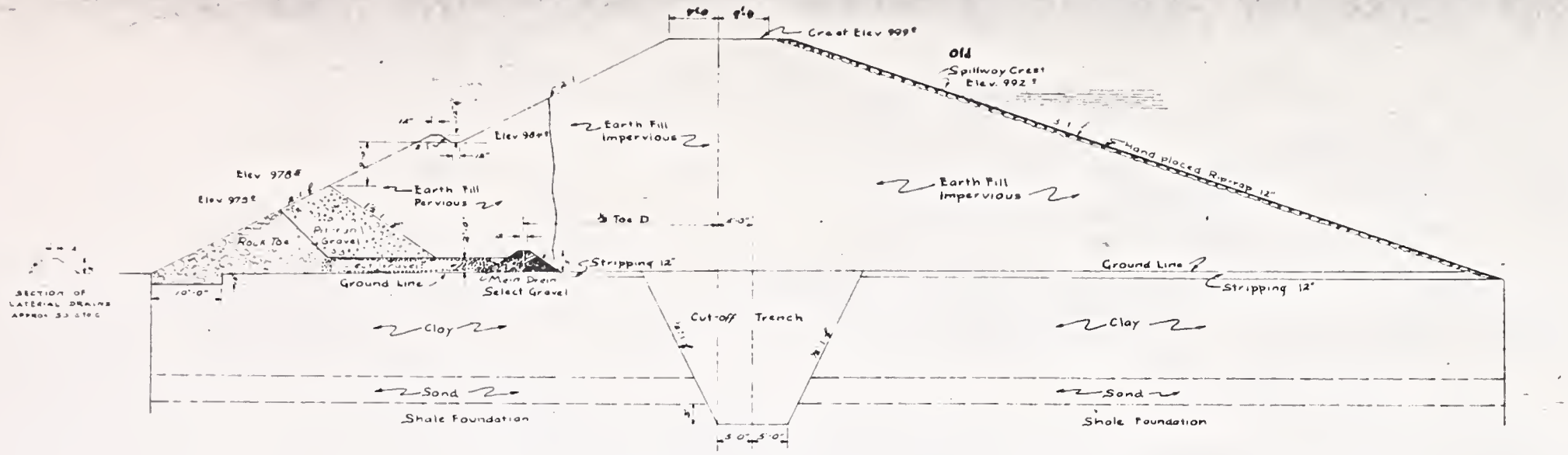
MAP of HIGH WATER CONTOUR
Scale 0.73" = 1 MILE

EXHIBIT DI SHEET 1

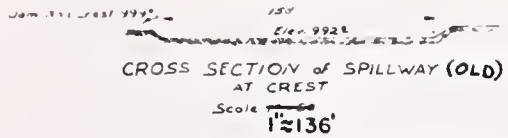
CONTOUR MAP YELLOW WATER STORAGE PROJECT				
REGION NINE				
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE H.H. BENNETT, CHIEF				
LOCATION: PETROLEUM COUNTY, MONT.				
DRAFTING APPROVAL			TECHNICAL APPROVAL	
Traced 30 dan 1956 RHF				
COMPLD.	TRACED J.L.S	CHECKED	DATE 3-27-59	FILE NO. P-995



DAM NO. 2
Crest of Dam 999.0
DAM NO. 1
Crest of Dam Elev. 999.0
Water Level Elev. 992.0
Old Spillway Crest
Old Spillway
Clay
Clay & Shale
Sandstone
Orignal Ground Line
Sandy Shale
Shale Foundation
Sandy Clay
Gravel
Sand
Bottom of Core Trench
PROFILE of DAM
Scale 1" = 275' HORIZ.
1" = 27.5' VERT.
DAM NO. 1
DESCRIPTION
QUANTITIES (Cu. Yds)
TO STATION
Stripping
Core Trench Exc
Drainage System
Pit-run Gravel
Toe-trench Exc
Rock Toe
Outlet Trench Ex
TO CONTOUR
Core Trench Fill
Outlet Trench Fill
Earth Fill (dam)
Rip-rap (dam)
Old Spillway Crest
Sandstone Ledges
Bottom of Coulee
Clay & Shale
OLD SPILLWAY PROFILE
Scale 1" = 27.5' VERT., 1" = 275' HORIZ.
OLD SPILLWAY LOCATION
(SPILLWAY MODIFIED IN SPRING 1979; SEE EXHIBIT D3)
DIKE SECTION
(DAM NO. 2)
DAM NO. 2
DESCRIPTION
QUANTITIES (Cu Yds)
TO STATION
Stripping
TO CONTOUR
Earth Fill
Rip-Rap
OLD SPILLWAY
DESCRIPTION
QUANTITIES (Cu. Yds)
TO STATION
Excavation
Rip-Rap
Axis of Dam
Lateral Drains
Rock Toe
Trench for Outlet
MAIN DAM
(DAM NO. 1)
PLAN of DAM
Scale 1" = 275'
EXHIBIT D1 SHEET 2
PLAN & PROFILE
YELLOW WATER STORAGE PROJECT
U.S. DEPARTMENT of AGRICULTURE
SOIL CONSERVATION SERVICE
H.H. BENNETT, CHIEF
LOCATION: PETROLEUM COUNTY, MONT.
DRAFTING APPROVAL
TECHNICAL APPROVAL
COMPLD
TRACED
CHECKED
DATE
FILE NO.

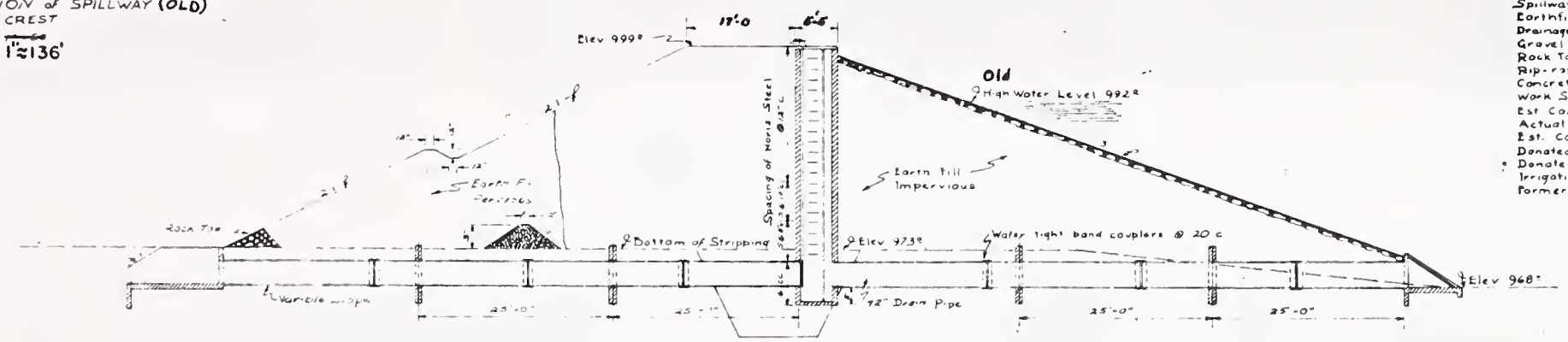


MAXIMUM CROSS SECTION of DAM
Scale 1" ≈ 27'



CROSS SECTION of SPILLWAY (OLD)
AT CREST
Scale 1"≈136'

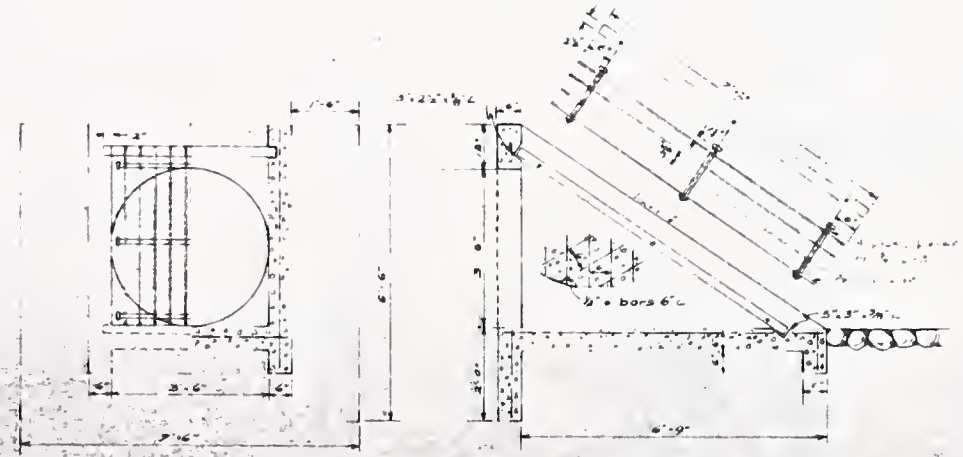
DESCRIPTION	QUANTITIES
Drainage Area	53 sq. M.
Storage	4,400 Ac. Ft
Lake Area	435 Ac
Flow	1800 C.F.S
Stripping	4,600 Cu Yds
Core Trench Exc	12,900 " "
Outlet Trench Exc	260 " "
Spillway Exc.	3,900 " "
Earthfill	115,000 " "
Drainage System - Gravel	950 " "
Gravel Fill	9,000 " "
Rock Toe	3,900 " "
Rip-rap rock	4,800
Concrete	20 " "
Work Started	Nov 12, 1935
Est Completion	Oct 1, 1936
Actual Completion	
Est. Cost	$29,00 Ac Ft
Donated Material	$5,000
Donated Equipment	$30,000
Irrigation	2,000 Ac
Farmers Benefited	30



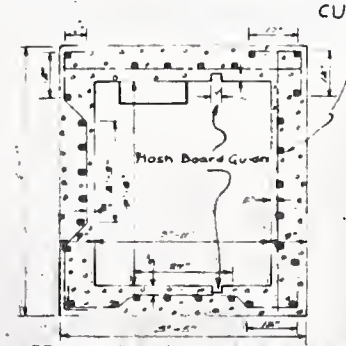
CROSS SECTION of DAM at OUTLET
Scale 1"≈27'

LADDER DETAIL
Scale 1"≈5.4'

CUT-OFF DETAIL
Scale 1" ≈ 10.8'



DETAILS of INTAKE & TRASH RACK
Scale 1"≈5.4'



SECTION THRU GATE WELL
Scale 1"≈5.4'

Vertical reinf. to consist of 1" ø bars placed as shown
Horizontal reinf. to consist of ½ ø bars bent and placed as shown and spaced as shown on section of dam. Straight bars to alternate with bent bars as shown.

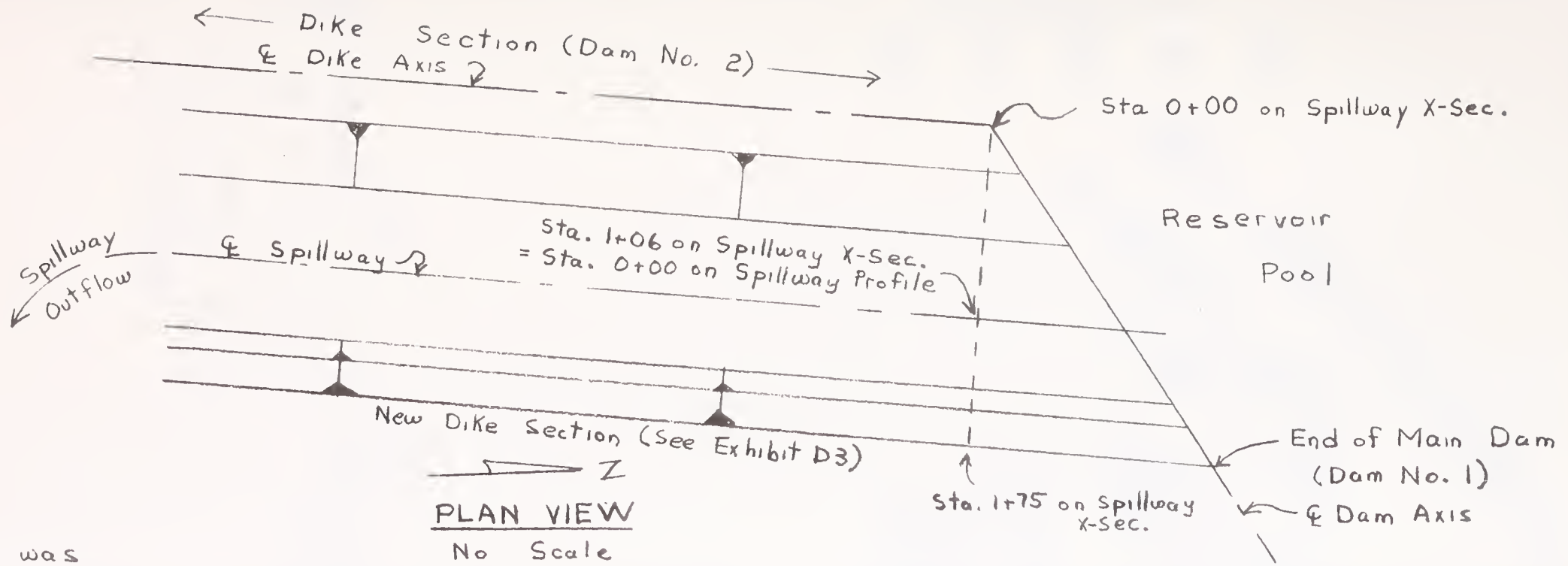
EXHIBIT D1 SHEET 3

SECTIONS THRU DAM
YELLOW WATER STORAGE PROJECT

SOIL CONSERVATION SERVICE
M.M. BENNETT, CHIEF

LOCATION: PETROLEUM COUNTY, MONT.

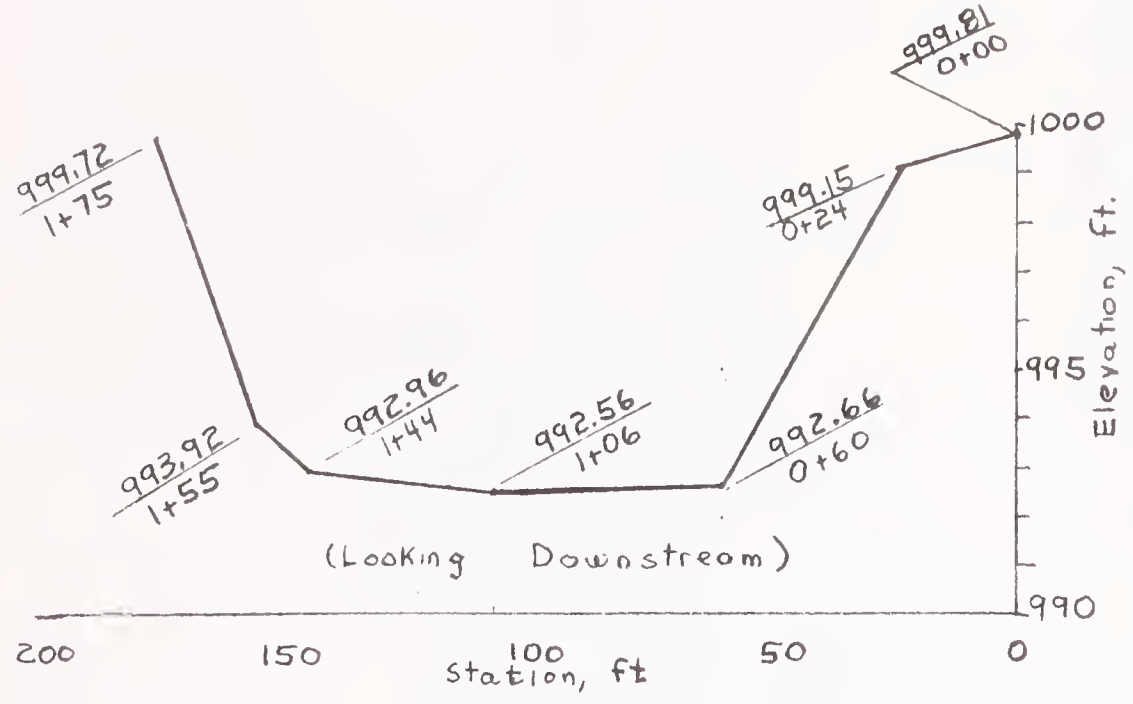
DRAFTING APPROVAL			TECHNICAL APPROVAL
COMPLD	TRACED J.L.S.	CHECKED	DATE 3-27-39	FILE NO. P-445



PLAN VIEW

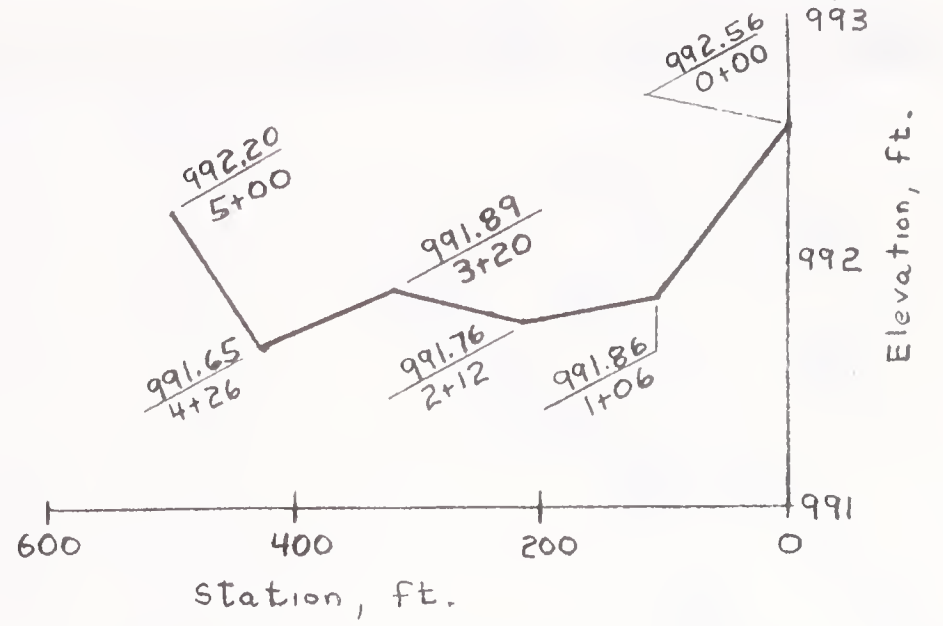
No Scale

Note:
Data shown here was gathered by HKM Assoc. during field survey Oct. 16, 1979



X-SECTION VIEW @ PROFILE STATION 0+00

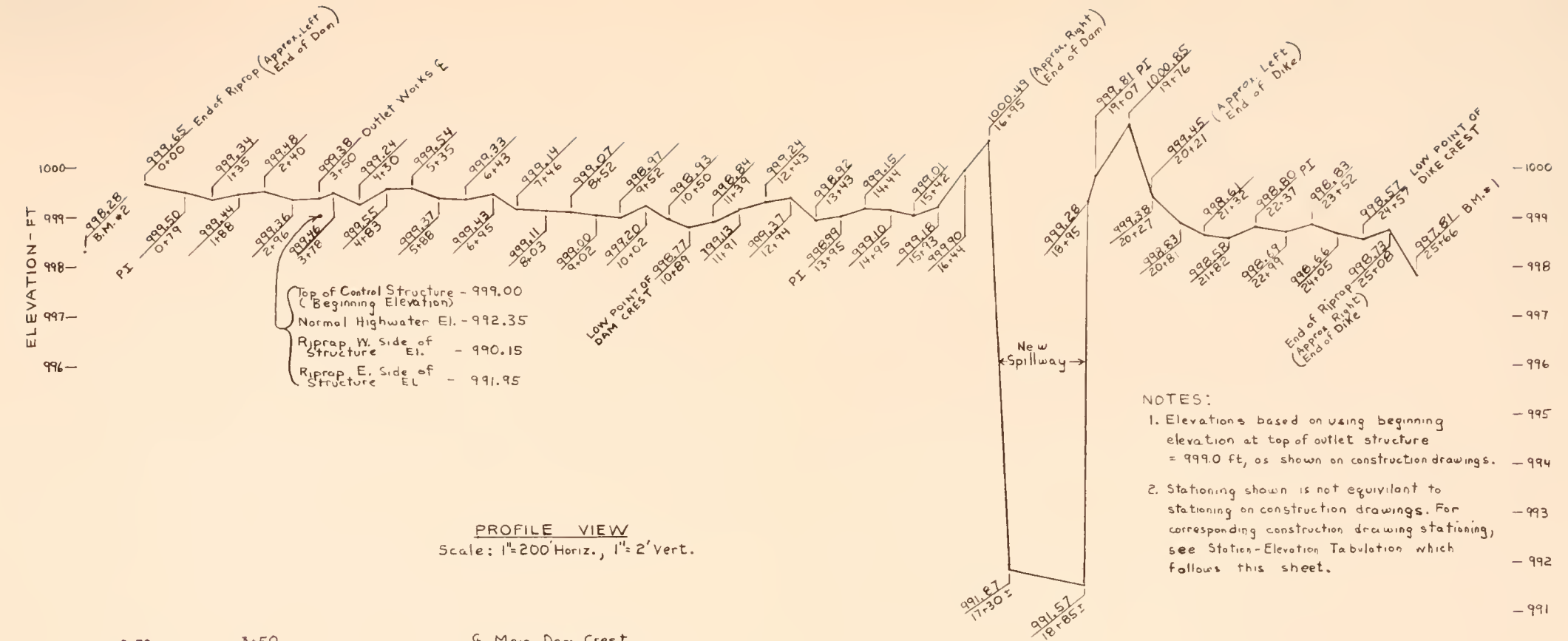
Scale: 1" = 50' Horiz., 1" = 5' Vert.



PROFILE VIEW ALONG SPILLWAY ℄

Scale: 1" = 200' Horiz., 1" = 1' Vert.

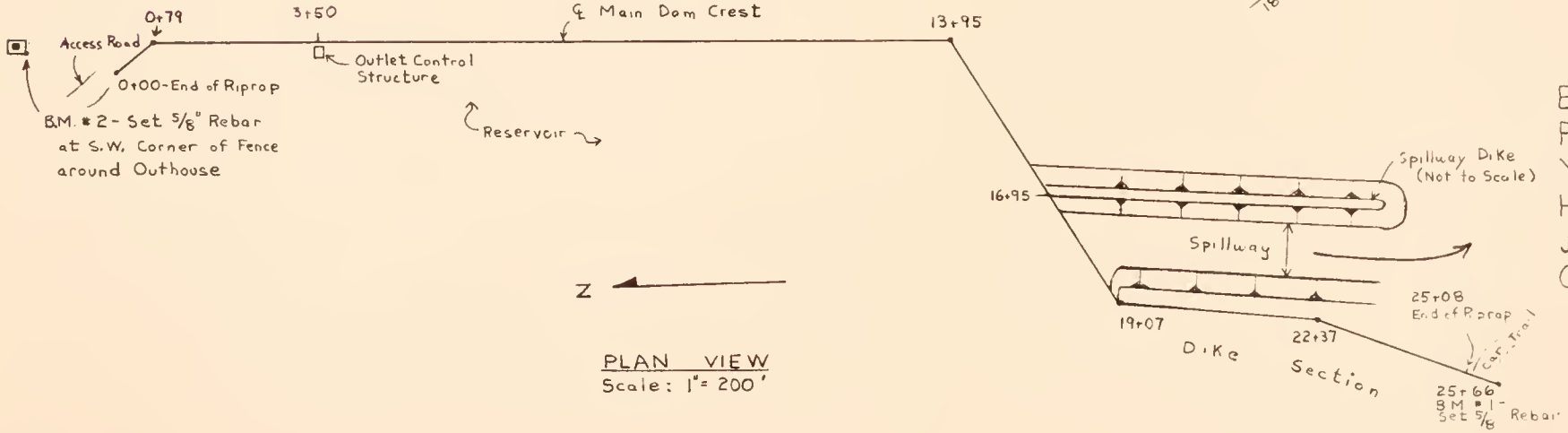
REVISED SPILLWAY (1979)
YELLOW WATER DAMS
EXHIBIT D1



PROFILE VIEW
Scale: 1"=200' Horiz., 1"=2' Vert.

NOTES:

1. Elevations based on using beginning elevation at top of outlet structure = 999.0 ft, as shown on construction drawings.
2. Stationing shown is not equivilant to stationing on construction drawings. For corresponding construction drawing stationing, see Station-Elevation Tabulation which follows this sheet.



PLAN VIEW
Scale: 1"= 200'

EXHIBIT D2
PROFILE ALONG CREST ℄
YELLOW WATER DAMS
HKM ASSOCIATES
JOB NO. 7M140.108
OCT. 16, 1979

HKM ASSOCIATES COMPUTATION SHEET

By	Date	Project No.	Sheet 1 of 2
DRC	11-8-79	7M140.108	
Chkd by	**Date**	**Name**	
		Yellow Water Dams	
Details		**Feature**	
		Station - Elevation Tabulation, Crest Survey	

STATION FROM 10-16-79 SURVEY (FT.)	CORRESPONDING CONST. DRWG. STATION (FT.) 1/	ELEVATION (FT.)	DESCRIPTION
		998.28	B.M. #2 - Set 5/8" Rebar at S.W. Corner of Fence around Outhouse
0+00	9+74	999.65	End of Riprap (Approx. Left End of Dam)
0+79	10+53	999.50	PI - Approx. Turning Point of Dam Axis
1+35	11+09	999.34	
1+68	11+62	999.44	
2+40	12+14	999.48	
2+96	12+70	999.36	
3+50	13+24	999.38	Approx. Outlet Works ℄
		999.00	Top of Control Structure (Beginning Elevation)
3+50	13+24	992.35	Normal Highwater El.
		990.15	Riprap W. Side of Structure
		991.95	Riprap E. Side of Structure
3+78	13+52	999.46	
4+30	14+04	999.24	
4+83	14+57	999.55	
5+35	15+09	999.54	
5+86	15+62	999.37	
6+43	16+17	999.33	
6+95	16+69	999.43	
7+46	17+20	999.14	
8+03	17+77	999.11	
8+52	18+26	999.07	
9+02	18+76	999.00	
9+52	19+26	998.97	
10+02	19+76	999.20	
10+50	20+24	998.93	
10+89	20+63	998.77	Low Point of Dam Crest
11+39	21+13	998.84	
11+91	21+65	999.13	
12+43	22+17	999.24	
12+94	22+68	999.37	
13+43	23+17	998.91	
13+95	23+69	998.99	PI - Approx. Turning Point of Dam Axis
14+44	24+18	999.15	

1/ NOTE: Stationing calculated from survey stations using survey station 3+50 = const. drwg. station 13+24 at outlet works.

EXHIBIT D2

HKM ASSOCIATES COMPUTATION SHEET

By	Date	Project No.	Sheet 2 of 2
DRC	11-8-79	7M140.108	
Chkd by	**Date**	**Name**	
		Yellow Water Dams	
Details		**Feature**	
		Station-Elevation Tabulation, Crest Survey	

STATION FROM 10-16-79 SURVEY (FT)	CORRESPONDING CONST. DRWG. STATION (FT) 1/	ELEVATION (FT)	DESCRIPTION
14+95	24+69	999.10	
15+42	25+16	999.01	
15+93	25+67	999.18	
16+44	26+18	999.90	
16+95	26+69	1000.49	Approx. Right End of Dam
17+30±	27+04	991.87	Bot. of Spillway at Dam Crest ℄
18+85±	28+59	991.57	Bot. of Spillway at Dam Crest ℄
18+95	28+69	999.28	
19+07	28+81	999.81	PI - Approx. Turning Point of Dam Axis
19+76	29+50	1000.85	
20+21	29+95	999.45	Approx. Left End of Dike
20+81	30+55	998.83	
21+32	31+06	998.61	
21+82	31+56	998.58	
22+37	32+11	998.80	PI - Approx. Turning Point of Dam Axis
22+99	32+73	998.69	
23+52	33+26	998.83	
24+05	33+79	998.66	
24+57	34+31	998.57	Low Point of Dike Crest
25+08	34+82	998.73	End of Riprap (Approx. Right End of Dike)
25+66	—	997.81	B.M. #1 - Set 5/8" Rebar

EXHIBIT D2

YELLOW WATER RESERVOIR

N

SCALE: 1" = 225' (APPROX.)

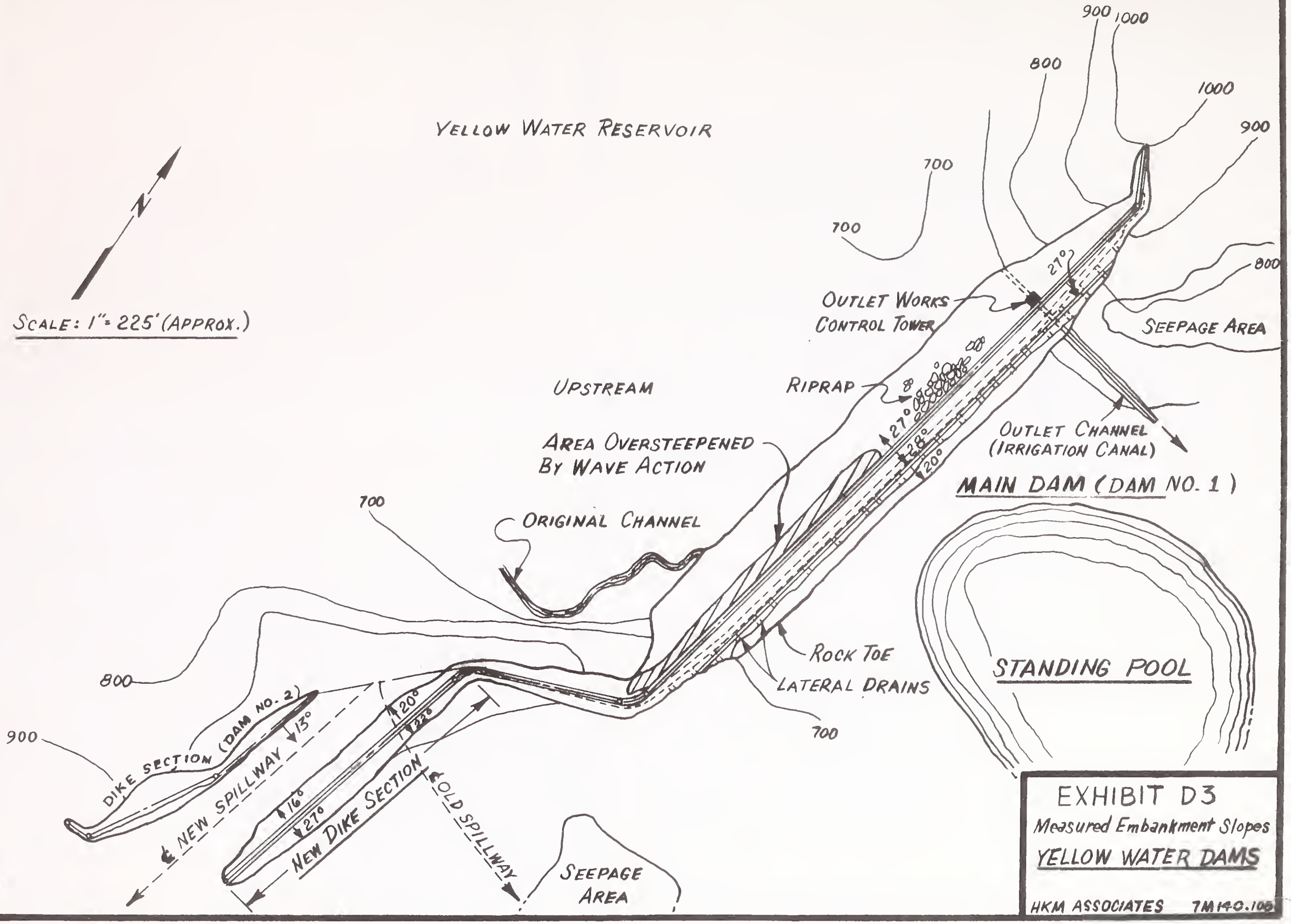


EXHIBIT D3

Measured Embankment Slopes

YELLOW WATER DAMS

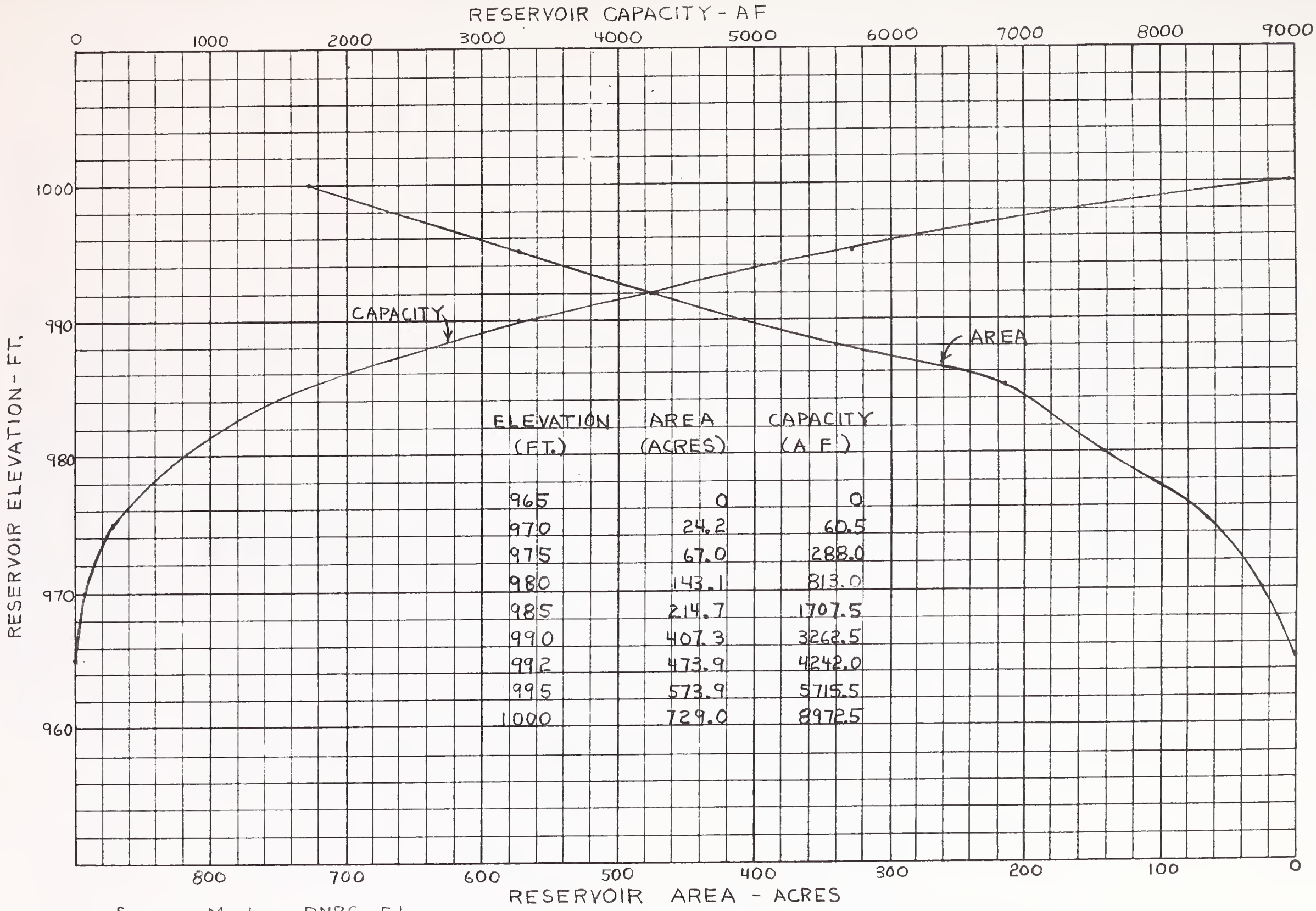
HKM ASSOCIATES 7M140.10

APPENDIX E

YELLOW WATER RESERVOIR

ENGINEERING DATA

EXHIBIT E1	RESERVOIR AREA - CAPACITY CURVE & TABLE
EXHIBIT E2	DISCHARGE RATING TABLE
EXHIBIT E3	DISCHARGE RATING CURVES



ELEVATION (FT.)	AREA (ACRES)	CAPACITY (A F)
965	0	0
970	24.2	60.5
975	67.0	288.0
980	143.1	813.0
985	214.7	1707.5
990	407.3	3262.5
992	473.9	4242.0
995	573.9	5715.5
1000	729.0	8972.5

Source : Montana DNRC Files

EXHIBIT E I
RESERVOIR AREA-CAPACITY CURVE & TABLE
YELLOW WATER DAMS

EXHIBIT E2

DISCHARGE RATING TABLE

YELLOW WATER DAM

Elevation (Ft)	Outlet Works Q(cfs) [1/]	Spillway Q(cfs)	Total Q(cfs)
968	0		0
972	51		51
974	70		70
976	85		85
978	98		98
980	109		109
982	119		119
984	128		128
986	137		137
988	145		145
990	153		153
992	160		160
992.6 (Present Spillway Crest)	163	0	163
993	164	10	174
994	168	240	408
995	171	700	871
996	174	1320	1494
997	178	2000	2178
998	181	2870	3051
999	184	3900	4084

[1/] Rating analysis assumes control gates at centerline dam axis in fully open position and "conduit control" exists throughout the total range of flows examined.

OUTLET WORKS Q (cfs)

0 25 50 75 100 125 150 175 200 225

999

FIRST OVERTOPPING
DIKE CREST EL. 998.6'

SPILLWAY

OUTLET WORKS

995

990

985

980

975

970

968

ELEVATION (feet, local datum)

0 1 2 3 4

SPILLWAY Q (1000 cfs)

EXHIBIT E3
YELLOW WATER DAMS
DISCHARGE RATING CURVES

APPENDIX F

YELLOW WATER DAM

CORRESPONDENCE

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR

32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872

HELENA, MONTANA 59601

July 28, 1980

Ralph Morrison
Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Mr. Morrison:

The Department of Natural Resources and Conservation has reviewed the final draft report on Yellow Water Creek Dam (MT-12) and Yellow Water Dike (MT-3205). We concur with the findings and recommendations as set forth by HKM and Associates in the report and feel that the report satisfies the criteria for the Phase I evaluation. Minor comments have been discussed with your staff and we understand that they will be included in the final report.

We sent copies of the final draft report to the Yellowwater Users Association for their review and we are enclosing a copy of their comments for inclusion in the final report.

Thank you for the opportunity to review and comment on the final draft report for this project.

Sincerely,

Richard L. Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB/lj
Enclosure

Winnett, Montana
July 9, 1980

Natural Resources Board
Helena, Montana
Dear Sirs,

The board of directors of Yellowwater users Association held a meeting to discuss the report from the Corp of Engineers on the Yellowwater irrigation damm The following remarks are the feeling of the board.

They are of the opinion that this report of being completely unsafe is out of proportion.
We do know the outlet pipe needs some more work on it and that part is in the planning stage and will be taken care of this fall after the irrigation season is over.

The riprap that has slipped slightly will be added onto in due time.

The idea of the spillway being to small we are sure is wrong as it is the same size as it has always been, it has been repaired and is in excellent condition.
It has only been used three times in the past 44years of operation and not to any great extent those times.

If it should come a rain in this arid country in the amount is talked about in the report the whole country would be afloat and no one would have time to be concerned about an irrigation project.

If you have any further questions we would be more than happy to try and find the answers to them.

Yours truly,
Floyd R. Hill Sec.